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INSECTICIDES AND EQUIPMENT FOR CONTROLLING INSECTS ON FRUITS AND VEGETABLES

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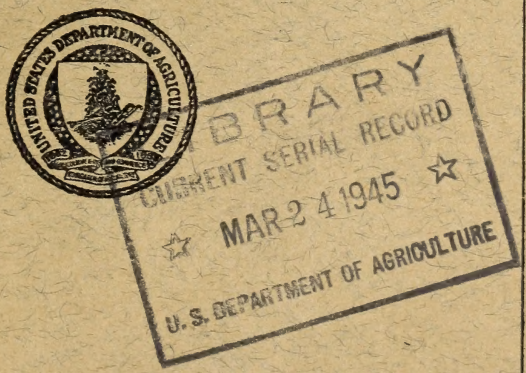

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INSECTICIDES AND EQUIPMENT FOR CONTROLLING INSECTS ON FRUITS AND VEGETABLES

By N. F. Howard and C. A. Weigel, *senior entomologists, Division of Truck Crop and Garden Insect Investigations,* C. M. Smith, *senior chemist, Division of Insecticide Investigations,* and L. F. Steiner, *senior entomologist, Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.*

CONTENTS

605160°—45——1

INTRODUCTION

Adequate food supplies have an essential place in the successful conduct of the war. Insects should not be permitted to reduce the increased yields required to supply necessary food. The national effort to increase food production necessitates that those who serve as advisers on production programs be informed on the sources, supplies, and uses of the chemicals, or insecticides, needed to control insect pests. This publication has been prepared for this purpose. It will be useful, also, to market gardeners, fruit growers, nurserymen, florists, and others concerned with the control of insects by insecticides.

Specifically, this publication deals with the nature of the chemicals more commonly used to control insects on fruits, vegetables, and flowering plants, and gives information on how to prepare such insecticides for use against many common pests. A section is devoted to a discussion of spraying and dusting equipment.

Most insecticides will become scarce as stocks are depleted and replacement becomes difficult. It is not only thrifty, but patriotic as well, to use them carefully. Careful application of minimum amounts will do a better job than careless use of large quantities.

The aim should be to mix the material thoroughly and apply it as a light, even coating to the parts of the plant affected by the insect. Applying the material to the parts affected saves material and insures effective control of the pest.

For more specific information on the control of any pest, the entomological publications of the State or Federal Government, or a State or Federal entomologist, or an entomologist of some other organization, should be consulted. If the pest is not identified, preserved or dead specimens of the insect or a description of its injury should accompany the request for information on control.

PRECAUTIONS IN USING INSECTICIDES

Most chemicals used as insecticides are poisonous to man and other animals and should be handled accordingly. When mixing or applying insecticides, take extreme care to keep the materials out of the mouth and eyes and away from tender parts of the body. When spraying or dusting operations are long and continuous, keep the body well covered, even in the warmest weather, and wear goggles to protect the eyes.

Small quantities of spraying or dusting materials which come in contact with the hands or body will be of little consequence, but accumulations of such materials resulting from long exposure are harmful.

In any event, wash the face and hands thoroughly after using any insecticide. After long exposure it should be the practice to take a bath and change the clothes, and this should be done both at noon and after the day's work. Residues should not be permitted to accumulate on clothing. To avoid this, the clothing used in spraying operations should be washed frequently.

Containers in which insecticides are stored should be plainly marked "Poison" and the date of purchase shown. They should be kept tightly closed and in a specially selected place, preferably

under lock, and well out of reach of children and others unfamiliar with their poisonous nature. Every effort should also be made to prevent domestic animals and livestock from being poisoned by insecticides, either through feeding on treated vegetation, licking containers, or drinking water which may have been contaminated.

To aid in avoiding poisoning from the accidental use of white insecticides, some of them, particularly lead arsenate, calcium arsenate, and sodium fluoride, are now colored by the manufacturer.

Containers in which materials are being mixed or batches of prepared insecticides set aside for the moment should not be left open or exposed in such a way that roaming farm animals, in passing, can lick them. Empty packages and bags should be buried or burned. Unused portions or discarded material should be buried at least a foot below the surface and away from water supply or drainage. Horses, cows, sheep, and poultry should be prevented from feeding or grazing under trees that have been sprayed. Water from roofs that have been sprayed accidentally may also be a source of danger.

SPRAY RESIDUES ON PLANTS

Residues of certain insecticides on the harvested product may endanger the consumer's well-being and must be guarded against. The recommendations that follow are given as a guide in avoiding such risks.

Inorganic insecticides, such as the arsenicals and fluorine compounds, should not be sprayed or dusted on the edible foliage or fruit when the residues on the part used for food cannot be removed, either by washing or wiping, or by stripping off the outside leaves. These materials should not be applied to strawberries within 3 weeks of harvest, or to grapes and bramble fruits after the blossoms have opened and the berries have begun to form. Treatment after such time may leave dangerous quantities of residues on the harvested berries. Fruits such as apples may be washed in weak acid or alkaline solutions to remove excessive deposits. Unless they are to be washed in a manner that will remove excess amounts of insecticides, apples should not be sprayed with arsenicals or fluorine compounds after June.

The Federal Government prohibits the movement and sale of apples and pears in interstate commerce when residues of lead, arsenious oxide, and fluorine exceed certain prescribed limits. For lead the tolerance is 0.05 grain Pb per pound of fruit, for arsenic, 0.025 grain As_2O_3 per pound, and for fluorine, 0.05 grain F per pound.

Insecticidal residues cannot be removed satisfactorily from cabbage, lettuce, celery, spinach, cauliflower, turnip greens, kale, broccoli, or other greens by a superficial washing of the head or leaves. Such a washing may remove the residues from the outside smooth surfaces of the leaves or fruit, but the innermost parts among the folds or ribs will not be affected materially.

Cabbage.—Such materials as paris green, cryolite, and calcium arsenate should not be applied to any portion of the cabbage plant that is to be marketed. This means that cabbage intended for marketing as U. S. Grade No. 1 (which allows four loose outer leaves) should

not be sprayed with these materials after the head has begun to form. If the marketed product is to bear a greater number of loose outer leaves than those allowed in U. S. Grade No. 1, these materials should not be used after the plants have been thinned or transplanted. If all the outer leaves of headed cabbage have been removed, the remainder should be free of harmful residues.

Celery.—Arsenicals and fluorine compounds are not recommended for use on celery because of harmful residue.

Tomatoes.—Residues may occur on tomatoes treated with calcium arsenate or cryolite, but the washing process in the canneries and wiping the fruit for market with a cloth will practically eliminate these residues.

Beans.—For green and snap beans, sprays or dusts containing cryolite or arsenicals should not be applied after the pods have begun to form. If treatment is made after this period of growth, two or three washings of the harvested beans in water should remove any harmful residues.

Peppers.—All peppers that have been treated with an arsenical (calcium arsenate) or fluorine compound (cryolite) must be washed before they are marketed or processed.

INJURY TO THE PLANTS BY INSECTICIDES

Insecticides, especially when improperly prepared or applied, may injure the plant foliage and flowers. Promiscuous spraying is therefore very inadvisable. Insecticides are seldom if ever beneficial to the plant itself, and they are good and useful only insofar as they remove the dangerous and destructive pests with a minimum of damage to the plant.

The choice and purity of the materials and the care exercised in their preparation and application influence the results obtained. The margin of safety between the effective dosage required to kill the insect and the tolerance of the plant to the insecticide is often very narrow. Some plants will tolerate more insecticides than others; for example, beans are likely to be damaged by treatment with arsenicals, whereas potato and cabbage will withstand comparatively large dosages of such materials without injury. The factor of plant tolerance, therefore, as well as the effect of the insecticide on the insect, must be considered in pest control. Oftentimes the plant tolerance limits the general use of an insecticide. For example, lead arsenate and calcium arsenate will control the Mexican bean beetle, but under certain climatic conditions both these materials may cause plant injury. Magnesium arsenate, while satisfactory on beans under most conditions, will cause plant injury to peach and apple trees. Hydrated lime is used with the arsenicals as a means of offsetting foliage injury; but it should not be used with the fluorine compounds, with which it is not compatible.

Sulfur, applied either as a dust or a spray, may cause injury to the foliage of squashes, melons, and cucumbers, and to the fruits of raspberry, as well as to the tender growth and blossoms of roses and various other flowering plants.

Many plants will not tolerate oil sprays, especially when repeated applications are necessary.

Rotenone- and pyrethrum-containing sprays and dusts, and hellebore, are tolerated by most plants and rarely cause injury.

Either sodium fluosilicate or barium fluosilicate, even when diluted with five times its weight of clay as for the control of blister beetles, will cause injury under some conditions, and many plants will not tolerate them. Cryolite applied at the recommended dosages is normally tolerated by most plants, but corn is particularly sensitive to this material as well as to other fluorine compounds. Sodium fluoride should not be used as a plant insecticide, as it may destroy the plant.

Soap sprays, especially when used at high concentrations, will injure the leaves of such tender plants as young cabbage or cauliflower in seed beds, or garden peas and young beans, as well as many tender ornamental plants.

The dosages of insecticides recommended in this publication are based, in general, upon the minimum quantities that will control the insects and that are within the range of dosages the plants will tolerate.

ARSENIC TRIOXIDE

Arsenic trioxide (As_2O_3), or arsenious oxide, is a crystalline material usually sold as "white arsenic." It is largely obtained as a by-product in the flue dust from smelters. In normal times our supply comes from both domestic and foreign sources. In somewhat impure forms it is marketed as off-white arsenic under names indicating its color, such as gray arsenic. Arsenic trioxide is the starting material in the manufacture of the arsenical plant insecticides. Because of its adverse effect upon plant tissue it is not used as a plant insecticide, but is used in the compounding of poisoned baits for the control of grasshoppers and cutworms and certain other insects. (See Poisoned Baits, p. 28.)

Caution.—Arsenic trioxide is a violent poison and must be stored in a safe place and in plainly labeled containers. The powder should not be inhaled, and it should not be permitted to come in contact with the skin, especially open wounds.

BARBASCO

See Rotenone-containing Roots (pp. 30–32).

BARIUM CARBONATE

Barium carbonate ($BaCO_3$), a domestic, natural, chalklike substance, is ground to a powder and used as an insecticide in some cases, but it is better known as a rat poison. Rather heavy dosages are required to protect plants from attack by chewing insects, such as the Mexican bean beetle (½ pound to the gallon of water).

Caution.—Barium carbonate is poisonous to man and animals when taken into the intestinal tract, and care should be exercised in handling it.

BARIUM FLUOSILICATE

Barium fluosilicate ($BaSiF_6$), a domestic product, has been used against some insects. While somewhat useful in the control of the

Mexican bean beetle, when used at the rate of 6 pounds to 100 gallons of water, it is of more value against flea beetles and blister beetles. It may cause foliage injury. To reduce foliage injury, alkaline waters and those containing sulfates should not be used with this material.

Caution.—Barium fluosilicate is very poisonous to higher animals and man. Observe care in its use. For spray-residue tolerance see page 3.

BENTONITE

Bentonite is a naturally occurring, light-colored clay. Chemically, it is chiefly a hydrous silicate of aluminum, calcium, and magnesium; but a variety of other compounds may be present, depending upon the source of the material.

There are two general classes of bentonites, the swelling and the nonswelling. The former is used to dilute insecticidal and fungicidal dusts, as an emulsifier for home-mixed oil emulsions, and in the preparation of tank-mixed and proprietary nicotine bentonite sprays.

The principal source of the swelling type is the Black Hills region of Wyoming and South Dakota, and the name "Wyoming bentonite" is generally used to distinguish it from nonswelling clays. When wet it will absorb water and swell to from 7 to 11 times its dry volume, forming a gelatinous mass.

Other bentonites which absorb water and swell to not more than 2 or 3 times their dry volume are mined in Arkansas, California, Georgia, and Mississippi.

Most of the swelling types of bentonites will react with nicotine to form a nicotine bentonite in which part of the nicotine is insoluble in water, so that the combination acts as a stomach poison rather than a fumigant or contact insecticide. At present Wyoming bentonite is preferred for use with most insecticides, although certain of the low-swelling types from Mississippi have recently come into use. These are obtainable as a fine powder, while the Wyoming bentonites may be obtained either in powder form, which is preferred when used as a diluent, or in pellets for use in making tank-mixed oil emulsions or nicotine bentonite sprays. (See Nicotine Bentonite, p. 24, *also* Mineral Oil, p. 20.)

BETA NAPHTHOL

Beta naphthol ($C_{10}H_7OH$) is a slowly volatile, crystalline compound that is used to impregnate corrugated paper bands, for placing around the trunks of mature apple trees to trap and kill codling moth larvae.

Rolls of single-faced corrugated paper 2 inches wide may be dipped in a hot (250° F.) solution of 1 pound of beta naphthol (technical) in 1.5 pints of lubricating oil having a Saybolt viscosity of 100–300 seconds at 100° F. The mixture can be used cold if diluted with gasoline. The chemical coating should be from 0.3 to 0.5 ounce of beta naphthol plus oil per linear foot of band, the smaller quantity being used in the Pacific Northwest.

Some persons with delicate skin are very sensitive to beta naphthol and may experience a burning sensation when working with it, but the effect is only temporary. Gloves may be worn to avoid this.

Prepared bands may be purchased in 250-foot rolls.

BORDEAUX MIXTURE

Bordeaux mixture is the name applied to sprays made by reacting dilute solutions of copper sulfate (bluestone) with lime. Home-made

bordeaux mixture should be freshly prepared when used. Ready-prepared mixtures are available on the market.

This spray has a blue color and leaves a bluish-white deposit on sprayed surfaces. Its sticking properties are excellent. It is used as a control for the potato leafhopper on potato and as a repellent for flea beetles on various vegetable and flowering plants. Bordeaux mixture is essentially a fungicide and as such is often combined with various insecticides such as nicotine, lead arsenate, calcium arsenate, and others.

It is also used as a safener for lead arsenate on apple foliage and as an emulsifier for tank mixtures of lubricating-oil sprays on dormant apple, pear, quince, prune, plum, and peach trees.

Various formulas for making bordeaux mixture are used. The following is one that is often recommended:

	For 100 gallons	*For small quantities*
Copper sulfate (bluestone)	8 pounds.	4 ounces.
Fresh hydrated lime	12 pounds.	6 ounces.
Water	100 gallons.	3 gallons.

On tender plants that would be injured by the above spray it is advisable to use half the quantities of copper sulfate and lime indicated in the formula.

When used as a safener for lead arsenate on apples, it may be reduced in strength to ½ or ¾ pound of copper sulfate with 1 or 1½ pounds of lime, respectively, per 100 gallons. The use of bordeaux mixture on apple foliage should be avoided in cool, wet weather, since under such conditions it may cause severe russeting of fruit.

Powdered copper sulfate is preferable to the crystal or lumpy forms for use in making bordeaux mixture, since it is readily soluble in cold water. When power sprayers are used the required quantity of the powdered copper sulfate is poured, or washed through a screen, into the partly filled sprayer in which the agitator is kept running. After the copper sulfate is completely dissolved, the lime is added either as a dry powder or in the form of a water-mixture. The remainder of the required quantity of water is then added to the tank and the agitation maintained while this is done. When small quantities are needed for use with compressed-air or knapsack sprayers, the total quantity of water to be used is divided and placed in two pails. The powdered copper sulfate is dissolved in one pail, and the lime mixed with the water in the other. Then the copper sulfate solution and the lime-water mixture are poured together and thoroughly mixed. The mixture is then poured through a strainer into the sprayer. If copper sulfate crystals or lumps are used, they should preferably be dissolved in a quantity of hot water representing one-half the total volume desired. If hot water is not available, place the copper sulfate crystals in a cloth sack and suspend this in the vessel containing cold water in such a way that the bottom of the sack is just below the surface of the water. Complete solution should occur in 1 to 2 hours. The suspension of lime in the other half of the water is then added, as the mixture is being agitated, and the whole poured through a strainer into the sprayer.

For convenience or where large quantities of bordeaux mixture are needed, stocks of copper sulfate solution and lime suspension may

be prepared, the former at 1 pound per gallon, the latter at 1½ pounds per gallon. These must be stored in tightly covered earthenware, wood, or glass containers. Equal quantities (the lime suspension being well mixed before the measured volume is removed) of these preparations can then be diluted, each to one-half the volume desired, and mixed to form bordeaux mixture. One gallon of finished mixture will require 1⅓ cupfuls of each preparation; 3 gallons, 1 quart of each.

Caution.—Bordeaux mixture may cause gastric disturbances if taken internally. All unused portions should be disposed of or covered so that they will be inaccessible to children and animals. It is also somewhat irritative to the eyes and skin.

CALCIUM ARSENATE

Commercial calcium arsenate sold for insecticidal purposes, unlike lead arsenate, is not a single chemical compound but a complex mixture of several arsenates and an excess of lime, whose proportions vary considerably between brands and even between different lots of the same brand. However, it usually contains the equivalent of from 40 to 42 percent of arsenic pentoxide. Calcium arsenate absorbs carbon dioxide slowly from the atmosphere during storage and increases its content of water-soluble arsenic oxide, unless it is packed in containers that are practically airtight. This change, however, is relatively unimportant.

The domestic manufactured calcium arsenate is a white powder, but when sold as an insecticide it is usually colored pink for the purpose of marking it as a poison. It is used as a spray at the rate of 1½ to 3 pounds per 100 gallons of water, in much the same manner as lead arsenate (p. 16), but it is more generally employed as a dust. As a dust it is used principally and in immense quantities in the undiluted form on cotton to control the boll weevil. Likewise in the undiluted form as a dust it is one of the best controls for the tomato fruitworm. Calcium arsenate is sometimes used for the control of cabbage caterpillars, the Mexican bean beetle, Colorado potato beetle, pepper weevil, codling moth, apple maggot, grape rootworm, grape berry moth, and cherry fruitfly, and to a limited extent on flowering plants. Applications on peppers, potatoes, cabbage, and cotton may result in heavy aphid infestations. It is more likely to injure foliage than is lead arsenate, but it is less objectionable from a residue standpoint because of the absence of lead. It is less effective than lead arsenate against the codling moth. Since it is likely to cause foliage injury, three or four times its weight of hydrated lime is often added to render it safer to use.

Caution.—Like all arsenical compounds, calcium arsenate is very poisonous to man and higher animals, and should be clearly labeled and stored away from any food products. It should not be applied to the edible parts of fruits and vegetables unless a long period intervenes before harvest or unless acid washes are used to remove the arsenical.

CALCIUM CYANIDE

Calcium cyanide ($Ca(CN)_2$) reacts with moisture in the air and gives off the deadly poisonous hydrocyanic acid gas that is toxic to

many kinds of insect pests. The gas is colorless, lighter than air, and has an odor resembling that of peach kernels or crushed almonds. A granular product containing about 42 percent of $Ca(CN)_2$ is used for fumigation, especially in greenhouses, where the material is sprinkled on the walks or soil at dusk after the ventilators have been closed. It is used against greenhouse pests, such as aphids, the Mexican mealybug, whiteflies, and the broad mite, at low dosages of $\frac{1}{8}$ to $\frac{1}{4}$ ounce per 1,000 cubic feet of air space, preferably at temperatures of 60° to 75° F. At higher dosages, thrips, scale insects, mealybugs in general, and various bulb pests are also destroyed. Plants vary considerably in their tolerance to the gas, and the margin of safety between a fatal dose for an insect and a plant is very narrow, therefore it must be used with care.

Calcium cyanide is used as a fumigant for the control of thrips and mealybugs on gladiolus corms, at the rate of 5 ounces per 1,000 cubic feet of space with an exposure of 2 hours. The corms should be warmed to at least 60° F. just prior to the fumigation and held at that temperature during the fumigation.

Colonies of ants in the ground may be controlled by dusting powdered calcium cyanide into their nests or pouring a teaspoonful into each of several holes about an inch in diameter, made with any convenient instrument, about 6 inches deep and spaced 1 foot apart. Openings of the holes should be closed, but treated areas should not be covered with papers, since the poisonous hydrocyanic acid gas may injure the grass or other vegetation.

Caution.—Hydrocyanic acid gas, from whatever source derived, is very poisonous to all animals and plants. (See also Sodium Cyanide, p. 33.) Therefore the calcium cyanide dust should be kept in tight containers, labeled plainly, and stored in a dry, safe place. This fumigant should be used only by those thoroughly familiar with its poisonous nature to humans and with the tolerance of different plants to the gas.

CARBON DISULFIDE

Carbon disulfide (CS_2) is a heavy, colorless or faintly yellow liquid. It has a disagreeable odor and is very volatile, the boiling point being only 115° F. The vapors are poisonous and very inflammable, and are explosive when mixed with air in certain proportions. They will sometimes become ignited from contact with hot steam pipes.

Carbon disulfide is used as a soil fumigant or as an emulsion against grubs of the Japanese beetle, white grubs, wireworms, and colonies of ants in the ground. To control ants in lawns, make holes about 3 inches deep in the soil with an iron bar or sharpened stick, spacing the holes about 1 foot apart throughout the entire infested area. Into each hole pour 1 teaspoonful of carbon disulfide, then close the opening by pressing the earth in place with the heel. Where the ant nests occur in ground between stones of a walk, apply 1 or 2 tablespoonfuls in each hole. Carbon disulfide cannot be used safely near growing plants.

Ant nests in trees may be destroyed by injecting carbon disulfide into openings to the galleries with an oil can and then plugging the openings with moist clay.

605160°—45——2

An emulsion of carbon disulfide is used for the control of white grubs, including larvae of the Japanese beetle, in the lawn and flower border. The emulsion contains—

Resin fish-oil soap	1 tablespoonful.
Water	3 tablespoonfuls.
Carbon disulfide	10 tablespoonfuls.

Place the soap and water in a quart bottle and shake until the solution is uniform. Then add the carbon disulfide and shake for 1 or 2 minutes or until a creamy emulsion has formed.

To treat the soil, stir 4 teaspoonfuls of this emulsion into a gallon of water, or the entire quantity into 11 gallons of water, and apply with a sprinkling can at the rate of 3 pints per square foot. Carefully measure the area to be treated and apply the emulsion uniformly without excess in any part, otherwise injury to grass roots or other plants will result.

If the lawn is kept moist for several days prior to the application of the insecticide, the grubs will tend to feed near the surface, where they can be reached by the emulsion.

Caution.—Because of its inflammability and poisonous nature, the greatest caution should be used in handling carbon disulfide. It should be kept in tightly closed containers, in a cool place, and away from fire, lighted cigarettes, and hot pipes. Because of the fire hazard, this chemical cannot be shipped by mail or express. Inhaling the gas causes dizziness and nausea, and the inhalation of large amounts is deadly. Some bureaus of the Department have discontinued the use of carbon disulfide for any purpose, and have issued regulations to that effect. The foregoing description of the chemical and the formula for compounding it with other substances must not be interpreted by the employees of those bureaus as justification for its use. These are included as a matter of general information to the public.

Carbon disulfide is manufactured in this country and is obtainable in small quantities in bottles or cans and in large quantities in steel drums.

CHLOROPICRIN

Chloropicrin (CCl_3NO_2) is a heavy, colorless, pungent, noninflammable liquid manufactured in the United States. This compound was used in the first world war as a lethal, tear, and vomiting gas. It has also been used for killing rats in ships.

Chloropicrin is used as a soil disinfectant for various disease organisms and nematodes in greenhouses and potting soil, and in small field areas where valuable crops are to be grown. When so used it also acts against other soil insect pests, including white grubs and the garden centipede (symphylid).

It destroys all plant growth in the immediate area. It is introduced into the soil by means of a special applicator.

It is applied at different concentrations according to the pests involved. Full directions for the use of this fumigant are usually furnished by the manufacturer.

The operator should wear a gas mask as a protection against the irritating fumes.

Chloropicrin may be purchased in 1-pound glass bottles or in cylinders of from 1 to 100 pounds capacity.

CRYOLITE

Cryolite, or sodium fluoaluminate (Na_3AlF_6), is a white crystalline chemical. Both natural cryolite imported from Greenland and synthetic materials of similar composition are available, and for most uses there is little difference between them. Large quantities are used in the control of the codling moth on apples in the semiarid valleys of the Pacific Northwest. Cryolite is also used for the control of the sugarcane borer, the tomato pinworm, the tomato fruitworm, the lima bean pod borer, the corn earworm and the Mexican bean beetle on beans, the apple flea weevil, the walnut husk fly, the pepper weevil, cabbage caterpillars, blister beetles, and flea beetles.

As a dust undiluted cryolite may be applied, but it is usually diluted with talc, pyrophyllite, or sulfur to contain from 40 to 70 percent of sodium fluoaluminate. As a spray it is used at the rate of 3 to 12½ pounds per 100 gallons of water, often with a small quantity of mineral or fish oil to improve its adhesiveness.

Cryolite should not be mixed with lime. It cannot be used with safety on corn or grapes, and it may cause injury to apples in the East and Middle West. Cryolite sometimes causes injury when applied to plants previously treated with soaps or with sprays containing arsenicals.

Caution.—Cryolite is a poison, and should be handled with care. This is one of the fluorine compounds, and the Federal tolerance for fluorine for apples and pears is 0.05 grain per pound of fruit.

CUBE

See Rotenone-containing Roots (pp. 30–32).

DERRIS

See Rotenone-containing Roots (pp. 30–32).

DICHLOROETHYL ETHER

Dichloroethyl ether, at the rate of 2 percent by volume, is used as a substitute for pyrethrins in highly refined white mineral oil for injection into the silks of sweet-corn ears for prevention of earworm infestation. It is a colorless liquid that mixes readily with mineral oil when shaken or stirred thoroughly. It is not so satisfactory as oleoresin of pyrethrum for use in earworm oil, because at comparatively low temperatures it sometimes fails to evaporate completely from the ears before they are used for food and thus may impart an undesirable flavor to them. (See Pyrethrum, or Insect Powder, pp. 29–30.)

DILUENTS OR CARRIERS

The ideal diluent for an insecticide in the powder form is one which is a suitable carrier for it and which functions satisfactorily in dusting machinery. The diluent, to be a suitable carrier, must be such that when mixed with the insecticide the two will remain as a homogeneous mixture both before and after discharge from the duster, or until the dust is deposited on the plant. It should also be compatible from the chemical standpoint, that is, it should not cause an undesirable chemical change in the insecticide with which it is mixed. The more commonly used materials listed below are all domestic products.

Bentonite.—See page 6.

China clay.—This material is also known as kaolin. It is a white, residual clay, and as marketed it is not a definite chemical compound but rather any one of several hydrated aluminum silicates.

Diatomaceous earth and kieselguhr.—These materials may be white, light gray, or pale buff. They are the siliceous remains of fossil diatoms.

Gypsum (landplaster).—Chemically this is calcium sulfate ($CaSO_4.2H_2O$), a white or yellowish-white powder. It is used with calcium arsenate in the control of cucumber beetles.

Hydrated lime.—See page 14. Chemically this is calcium hydroxide ($Ca(OH)_2$) and is commonly used with arsenicals and as a carrier in nicotine dusts.

Pyrophyllite.—Chemically this is anhydrous aluminum silicate ($HAl(SiO_3)_2$), white, and is very similar to talc in physical properties. It has recently come into general use as a diluent for cube and derris.

Sulfur.—See page 35.

Talc.—In the solid form this material is known as soapstone. Chemically it is a magnesium silicate ($H_2Mg_3(SiO_3)_4$). As marketed as an insecticidal diluent it is usually a white or grayish-white powder composed of microscopic platelike particles that give it a smooth feel. It is used in derris and cube dust mixtures.

Tobacco dust.—See page 37.

Walnut-shell flour.—This is a brown powder obtained by finely grinding the shells of Persian ("English") walnuts. It is used in the preparation of impregnated dusts. It is not so suitable as talc as a diluent for rotenone-containing roots (derris and cube).

Wheat flour.—This is the ordinary "white" wheat flour.

DINITRO COMPOUNDS

These are organic compounds manufactured in this country which have come into general use in certain fruit-growing districts for the control of scale insects, the fruit tree leaf roller, the pear psylla, the eye-spotted budmoth, mites, and aphids.

They are of two types, (1) those that are sold in powder form to be added by the grower to lubricating-oil sprays, and (2) those sold in liquid form to be added to water. The former group includes dinitro-o-cyclohexylphenol and dinitro-o-cresol. The principal compound in the second group is sodium dinitro-o-cresylate. Dinitro-o-cyclohexylphenol is also used on citrus as a contact insecticide in the form of a diluted dust to kill the citrus red mite, and it may be used on potato and bean to control the potato leafhopper.

These materials should be used according to the manufacturers' recommendations, since they may contain diluents in varying amounts.

The oil-soluble powdered forms, when added to dormant spray oils, generally reduce the quantity of oil required.

Dinitro insecticides as now used should be applied to deciduous trees only when the buds are dormant.

When properly used, these compounds present no special hazard to human health.

ESSENTIAL OILS

Essential oils are volatile, aromatic materials obtained from plants, usually by steam distillation, and have odors generally characteristic of the plant source.

They are employed as attractants in insect traps. The essential oils by themselves are relatively nontoxic.

Geraniol and eugenol are used in Japanese beetle traps; oil of sassafras (natural), bromostyrol, oil of anise, and geraniol in sugar solutions are used to trap codling moths. Terpenyl acetate and ethyl cinnamate in sugar solutions have proved very attractive to the oriental fruit moth. Amyl salicylate is used as an attractant for hornworm moths. Preservatives such as sodium benzoate, and poisons such as tartar emetic, sodium arsenite, and nicotine sulfate may be added to the sugar-aromatic combinations.

ETHYLENE DICHLORIDE

Ethylene dichloride (CH_2Cl-CH_2Cl), which is manufactured in this country, is a colorless liquid having a sweetish odor similar to that of chloroform. The vapor is heavier than air and penetrates the soil readily. The chemical burns with difficulty when ignited.

It is used in the form of an emulsion for control of the peachtree borer, the amount required depending upon the age and size of the tree. Prepared emulsions of ethylene dichloride are available on the market, or they may be made up as follows: Stir 9 parts by volume of ethylene dichloride into 1 part of a potash fish-oil soap containing about 30 percent of actual soap. Dilute and use as recommended by the county agricultural agent, State agricultural college, State entomologist, or the United States Department of Agriculture.

A mixture of 3 parts of ethylene dichloride and 1 part of carbon tetrachloride is used as a fumigant to control the gladiolus thrips on the dormant corms while in storage.

Caution.—When the vapor of ethylene dichloride is inhaled it has an anaesthetic action, although less rapid than that of chloroform. Unless it is breathed in high concentrations over a long period of time, no harmful results need be feared.

FISH OIL

Various domestic fish oils having iodine numbers of 120 to 145 are sometimes used as adhesives for lead arsenate in the control of the codling moth and gypsy moth.

Usually 1 pint of the oil and 3 pounds of lead arsenate are used per 100 gallons. The inclusion of 1 part of oleic acid in 19 parts of the fish oil generally improves the type of lead arsenate deposit obtained.

Fruit sprayed with lead arsenate and fish oil can be cleaned more easily with alkaline than with acid washes.

HELLEBORE

Hellebore, the ground root of the plant false hellebore (*Veratrum album* in Europe or *V. viride* in the southeastern part of the United States), is no longer much used, but formerly it was known to gardeners as a remedy for the control of sawflies on currant and gooseberry. For use as a spray, add 1 or 2 ounces of this material to a gallon of water. When used as a dust, 1 ounce of hellebore is diluted with 5 or 10 ounces of flour, talc, or lime. It has been used also as a larvicide for houseflies in manure.

It is not very poisonous to man but may cause discomfort if inhaled. It should be stored in tightly closed receptacles to prevent the loss of its toxic properties. The commercial product comes chiefly from the European species.

HOT-WATER TREATMENT

Immersion of plants, corms, or bulbs in heated water, maintained at a constant temperature ranging from 110° to as high as 120° F. for the period of treatment, is a method used in the elimination of a number of pests, including the gladiolus thrips, aphids, and mealybugs on gladiolus corms, the larvae of bulb flies and mites in narcissus and other bulbs, and the cyclamen mite in crowns and distorted growths of some ornamental plants.

The treatments for these pests vary, and publications dealing with each should be consulted for specific recommendations. Small quantities of bulbs or plants can be treated in a laundry tub or similar container, provided that an accurate thermometer is available for checking the temperature. In carrying out the treatment, fill the vessel three-fourths or more full of water, using sufficient hot water to bring the temperature up to the desired point. Submerge the plants or bulbs in screen boxes or loose net bags and add hot water to maintain the desired water temperature, as it is lowered by the cooling effect of material being treated or by radiation. After the bulbs or plants have been warmed to the desired temperature in the bath, less additional hot water will be required to maintain the temperature. If the treatment can be carried out in a warm room and the tank kept covered, the temperature will be more easily maintained. During the entire treating process the water should be stirred with a paddle frequently enough to maintain a uniform temperature throughout the container. Free circulation of the water should not be blocked by the treatment of too many plants or bulbs at one time. The duration of treatment is calculated from the time the temperature is brought up to the desired point after the plant material has been placed in the water.

The treatments required to control some common pests are:

The cyclamen mite and broad mite, 15 minutes at 110° F., except 20 minutes for large clumps of delphinium or gerbera and for trays of loosely placed strawberry plants.
Bulb mites on tuberoses, narcissus, and other bulbs, 1 hour at 110° F.
Bulb flies in narcissus and amaryllis, 1½ hours at 111° F.
The grape mealybug on gladiolus corms, 30 minutes at 116° F.
The gladiolus thrips on gladiolus corms, 30 minutes at 112° F.
The boxwood leaf miner on boxwood, 5 minutes at 120° F. during late fall and early spring.

HYDRATED LIME

Hydrated lime (calcium hydroxide, $Ca(OH)_2$) is a finely divided, white powder which can be distributed satisfactorily by dusting machines. Since this domestic product is low priced and readily available, it is used as a filler or diluent in many insecticidal and fungicidal dust mixtures, particularly those containing monohydrated copper sulfate, sulfur, or arsenicals. It is used in making nicotine dusts. Also, it acts as a safener in calcium arsenate-water sprays. In recent years

it has supplanted unslaked lime or quicklime, in the preparation of bordeaux mixture. It is commonly used by growers as a repellent to insects on melons, cucumbers, and other vegetables, and to repel the Japanese beetle on certain fruit crops, although, owing to its caustic nature, it may retard development of some plants. It is recommended for the control of slugs and snails.

For the preparation of bordeaux mixture the hydrated lime should be freshly made.

Hydrated lime is commonly used with zinc sulfate on peaches and with either zinc sulfate or copper sulfate on apples, as a safener for lead arsenate.

Caution.—The dust, when inhaled, is somewhat irritating to the respiratory passages. Keep containers well closed.

This material is usually available locally, in hardware stores or from dealers in building supplies.

KEROSENE EMULSION

Kerosene emulsion is an effective contact insecticide. It was in rather general use until replaced by the white-oil emulsions, which are safer to use on a wide variety of plants. If not properly prepared, kerosene emulsion may cause injury to succulent plants such as coleus, ferns, heliotrope, begonia, and crucifers, although it can be safely used on chrysanthemums, crotons, palms, and rubber plants.

Other, hardier plants are not injured, even by a 10-percent emulsion. A 5-percent emulsion is effective against mealybugs, rose midge larvae in the soil, immature scales, and red spiders, while a 1-percent emulsion can be used successfully against aphids, thrips, and ants in the soil. Kerosene emulsion should be applied preferably late in the afternoon and the plants thoroughly syringed with water the next morning before sun-up. Soil overrun with ants may be freed of these pests without injury to the plants by drenching the infested areas with a 1-percent emulsion.

A stock emulsion of kerosene is prepared according to the following formula:

	For large quantities	*For small quantities*
Kerosene	2 gallons.	1 pint.
Fish-oil soap or laundry soap	½ pound.	½ ounce.
Water	1 gallon.	½ pint.

If hard bar soap is used, first cut the soap into chips and then dissolve it in hot water, and while it is still hot add the kerosene very slowly, stirring constantly. The mixture should be pumped through a bucket pump back into the container for several minutes, or until a creamy emulsion has formed. Small quantities may be made with an egg beater.

The stock emulsion may be kept until needed in a tightly stoppered bottle or fruit jar. However, it will deteriorate with age and the kerosene will collect at the top of the mixture. This is the case with some of the commercial emulsions which have been prepared for some time. This free oil is the cause of much injury when applied to plants. The emulsion may be reclaimed by reheating and agitating, with or without the addition of soap.

To dilute the stock emulsion to the desired strength for spraying, the following quantities should be used:

Strength of spray desired	*Emulsion to make 1 gallon of spray*	*Emulsion to make 100 gallons of spray*
1 percent	4 tablespoonfuls.	6 quarts.
2 percent	8 tablespoonfuls.	3 gallons.
5 percent	1⅛ cupfuls.	7½ gallons.
10 percent	2⅕ cupfuls.	15 gallons.

Kerosene at the rate of 1 or 2 quarts per 100 gallons is sometimes used with lead arsenate for control of the codling moth. For this purpose it may be emulsified in the tank with bordeaux mixture, with some of the proprietary spreaders, or with the milder soaps. When used in this manner it acts primarily as an adhesive or deposit builder.

LEAD ARSENATE (ACID)

There are several chemically different compounds known as lead arsenate. Two of these are commonly used as insecticides. The one usually sold is "acid lead arsenate" (di-lead ortho arsenate, $PbHAsO_4$). The other, generally called "basic lead arsenate," is discussed on page 17. Both are fine powders and are readily kept in suspension in a spray. The residue tends to adhere strongly to foliage.

Acid lead arsenate should contain the equivalent of not less than 31 percent of arsenic pentoxide (As_2O_5). It should not contain more water-soluble arsenic than the equivalent of 0.5 percent of arsenic pentoxide.

Lead arsenate is manufactured in this country as a white powder, but since 1938 it and other white arsenicals have been colored pink when marketed as insecticides. This material is not quite so toxic to insects as is paris green but is much safer to apply on plant foliage. It is used both as a spray and as a dust, with a suitable carrier. Its most popular use is for control of the codling moth, plum curculio, apple maggot, pear slug, grape berry moth, and many other chewing insects attacking fruits. It is also used for many insects on flowers, trees, and shrubs, such as bagworms, beetles, weevils, and grasshoppers, and for the control of the Colorado potato beetle, beet webworm, and tomato hornworm. It also finds extensive use in treating soil to control Japanese beetle and Asiatic garden beetle larvae and related soil-infesting forms.

Lead arsenate is ordinarily used at dosages ranging from 2 pounds to 8 pounds per 100 gallons of spray. It may be used with other insecticides, such as nicotine and oil emulsion, or with fungicides like lime-sulfur, sulfur, and bordeaux mixture. It should not be used with sodium sulfide or potassium sulfide, or with most soap sprays. It should not be used on any vegetable crop where the portion treated is to be subsequently used for food, nor on fruits after the fruit has formed, except in instances where the interval before harvest is sufficiently long to permit the poison to be weathered off or where the residues will be removed at harvest by acid or alkaline washes. In some localities materials such as a weak bordeaux mixture or zinc sulfate and lime must be added to lead arsenate sprays to avoid injury to foliage. On beans this insecticide often causes plant injury and reduction in yield.

Caution.—Lead arsenate is a very poisonous compound and should be stored in plainly labeled containers away from all food products.

Both lead and arsenic residues on treated plants are poisonous. The Federal tolerance for lead on apples and pears is 0.05 grain per pound and for arsenic it is 0.025 grain of As_2O_3 per pound of fruit.

LEAD ARSENATE (BASIC)

Chemically, basic lead arsenate is lead hydroxy arsenate ($Pb_4(PbOH)(AsO_4)_3$). It should contain the equivalent of about 28 percent of total arsenic pentoxide (As_2O_5) and less water-soluble arsenic than the equivalent of 0.5 percent of arsenic pentoxide.

Like the much more commonly used acid lead arsenate, this material is a white powder which is colored pink when marketed as an insecticide to denote that it is a poison. Its use is virtually limited to particular areas on the Pacific coast and in eastern peach orchards, for certain chewing insects, where acid lead arsenate causes plant injury. It is less effective in controlling insects than is the acid form. Normally it is used at a rate of about 4 to 6 pounds to 100 gallons of water.

Caution.—Like acid lead arsenate, this material is toxic to man and higher animals, and should be stored in a safe place in clearly labeled packages.

The spray-residue tolerances for acid lead arsenate, as given above, apply also to basic lead arsenate.

LIQUID LIME-SULFUR AND DRY LIME-SULFUR

As the name implies, lime-sulfur is made from lime and sulfur. A complex mixture containing principally calcium polysulfides, it may be purchased in concentrated solution or as a dry powder, or it may be made on the farm. It is marketed in concentrated form as a deep amber-colored liquid, or as a yellow-orange powder. It is applied in the dilute form and is ill-smelling and irritating to the user.

Liquid lime-sulfur is used chiefly as a scalicide and a fungicide on fruit trees and woody shrubs. It is used extensively for the control of the potato psyllid in the Western States and is also valuable for the control of the peach twig borer, pear psylla, and pear leaf blister mite. As a scalicide it has been displaced in some localities by lubricating-oil sprays. When used in the dormant season to control scale insects it is applied at a strength of 10 to 14 gallons of the liquid concentrate in 100 gallons of spray. As a fungicide and as a spray for the common red spider and some other mites on plant foliage it is usually diluted to a strength of 2 gallons in 100 gallons of spray.

For control of the cyclamen mite on chrysanthemums and snapdragons, a lime-sulfur spray consisting of 1 to 2 quarts to 100 gallons of water with the addition of ¾ pint (1½ cupfuls) of a spreader—sodium oleyl sulfate containing a synthetic resinous sticker—has proved effective. This spray has the advantage of not staining the foliage as does lime-sulfur solution without the spreader.

For some purposes dry lime-sulfur may be substituted for liquid lime-sulfur at the rate of 4 pounds for 1 gallon of the liquid. *On*

deciduous foliage do not follow a sulfur spray with sprays containing oil until all sulfur residues have disappeared.

Directions for the preparation of self-boiled lime and sulfur and home-boiled lime-sulfur concentrate may be obtained from the county agricultural agent, the State experiment station or State entomologist, or the United States Department of Agriculture.

Caution.—Lime-sulfur sprays are very caustic to the skin, especially at the strengths used in the dormant season. Persons exposed to this material should protect their faces by covering them with grease or vaseline before they begin spraying, and should avoid getting any of the material into the eyes, where it will cause acute temporary discomfort. Don't allow lime-sulfur spray to drift onto painted buildings, or a very unsightly stain may result.

MAGNESIUM ARSENATE

Several compounds of magnesium oxide and arsenic oxide are known, and it has been reported that the commercial product sold as "magnesium arsenate" contains the dimagnesium salt, $MgHAsO_4$, and two basic salts, principally one having the composition $Mg_3(AsO_4)_2.MgO.H_2O$. There is also present a large excess of magnesium oxide or hydroxide, which is necessary to keep down the content of water-soluble arsenic.

Magnesium arsenate is a white powder but is colored pink when packaged as an insecticide to indicate its poisonous nature. It is used as a spray, at the rate of 4 pounds in 100 gallons of water, against the Mexican bean beetle. Derris and cube have largely replaced it for the control of this insect, but it can be used where these are not available, provided application is discontinued when the bean pods start forming. Magnesium arsenate is not used for the control of other insects. Its tendency to injure foliage is one drawback to its extensive use.

Caution.—Magnesium arsenate, like all arsenicals, is a poisonous compound and should always be so labeled, and stored away from all food products and out of the reach of children. For spray-residue tolerance, see page 3.

MERCURIC CHLORIDE

Mercuric chloride ($HgCl_2$) is known also as corrosive sublimate and as bichloride of mercury. It is soluble in water, but dissolves slowly unless the water is heated. Commercially it is available as a white powder, as crystals, and in the form of 7.5-grain tablets. The powder form is used commonly for insecticidal purposes.

A solution of 1 ounce in 7½ gallons of water or 1 level teaspoonful in 10 quarts of water, or two 7.5-grain tablets to 1 quart of water (1:1,000) is prepared by dissolving the compound in a small quantity of hot water and diluting it with cold water. This solution is used in the control of fungus gnats, earthworms in greenhouses, and the cabbage maggot. To avoid injury to the plant, keep the solution off of the foliage. Mercuric chloride is also used for the treatment of dormant gladiolus corms to control the gladiolus thrips. Other common uses are as a fungicide and a germicide.

Caution.—Mercuric chloride is a violent poison and must be stored in plainly labeled containers which are marked "Poison." It reacts with metals; and solutions should, therefore, be placed in wooden, earthenware, or glass containers. It is advisable to wear rubber gloves when working with this compound.

MERCUROUS CHLORIDE

Mercurous chloride (HgCl) is known also as calomel. It is a white powder insoluble in water.

Suspensions or mixtures of calomel in water are employed for the control of the cabbage maggot and the onion maggot, 3 or 4 ounces being used in 10 gallons of water. One ounce of gum arabic is generally added to 10 gallons of the mixture to keep the calomel from settling rapidly. The use of this material for the control of these maggots is preferable in some cases to the use of corrosive sublimate because of the highly toxic nature of the latter to man and animals.

Caution.—Mercurous chloride is not generally regarded as dangerously poisonous, being commonly used, in small doses, as a purgative. However, it should be stored in labeled containers out of the reach of children and irresponsible persons, since excessive doses are poisonous.

METALDEHYDE (SLUG BAIT)

Chemically, metaldehyde is a polymer of acetaldehyde, namely $(C_2H_4O)n$, and only recently has been manufactured in this country. It is available as a white powder which is insoluble in water but soluble in benzene and chloroform. The technical grade is available in tablet form.

Metaldehyde is very attractive to slugs and snails and is used in the bait form for these pests. It is prepared as follows:

Metaldehyde	1 ounce.
Bran or bread crumbs	3½ pounds.

To prepare the bait, mix the metaldehyde and the bran or bread crumbs and store the bait in a jar or other container until needed. When ready to use the material, place a portion of it in a pan and add water slowly, while stirring it, until the bait is moistened, yet remains crumbly when a handful is squeezed together.

At dusk this moistened bait is scattered over the beds that are infested with slugs, as described for applying poisoned-bran mash (p. 28). The treatment may be repeated in 2 or 3 weeks if the snails reappear, or if their injury and slimy trails are discovered.

After having eaten baits containing metaldehyde, the slugs are stupefied and finally die. Where the vegetation is dense and humidity is high, the affected snails are killed more slowly or they may recover. Under such conditions the following bait containing calcium arsenate is more effective and kills more rapidly than baits containing only metaldehyde:

	For small quantities	*For large quantities*
Calcium arsenate	1 ounce.	1 pound.
Metaldehyde	½ ounce.	½ pound.
Bran	1 pound.	16 pounds.
Molasses	2 teaspoonfuls.	1 pint.
Water	1 pint.	2 gallons.

In situations where no domestic or farm animals have access to the bait, apply it in piles of about a tablespoonful each, spaced about 2 feet apart; otherwise it should be scattered in the infested area as recommended for applying poisoned-bran bait (p. 28). Unless washed away by watering or rains it remains effective for some time, and baiting two or three times during the year gives adequate control. Ready-mixed baits containing calcium arsenate and metaldehyde are available on the market.

Caution.—Since metaldehyde may cause poisoning when taken internally, the containers should be plainly labeled "Poison" and kept out of reach of children and others.

METHYL BROMIDE

Methyl bromide (CH_3Br) at temperatures above 40° F. is a gas that is heavier than air. Under pressure it becomes a heavy, colorless liquid which is only slightly soluble in water. It is soluble in alcohol, chloroform, ether, and carbon disulfide. Commercially it has some use as a fire extinguisher and as a refrigerant. The gas is noninflammable, almost odorless, very penetrating, and is poisonous. As commercially produced it has a purity of 99½ percent or better.

For the destruction of insects and mites on plants and in soil methyl bromide is being used as a fumigant in specially constructed chambers. Under carefully controlled conditions of temperature, exposure, and dosage it will destroy these pests without injury to the plants. In this respect it is more useful as a general treatment than other fumigants.

Special fumigation chambers and special instructions are necessary for its proper use. Information on these points can be furnished, to those who have need for it, by the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C.

Caution.—When working with methyl bromide it is necessary to use a gas mask provided with a canister that will absorb the gas. It is toxic, and should not be allowed to come into contact with the skin. Containers of this gas should be stored in a cool, well-ventilated place outside of inhabited buildings. The gas is practically odorless, but dangerous concentrations of it may be readily detected by the use of a specially devised halide leak detector or lamp.

Methyl bromide is obtainable in small 1-pound cans or in cylinders containing 10, 50, or 150 pounds net.

MINERAL OIL

Mineral oil, or petroleum oil, is obtained by refining native crude oil. Refined petroleum oils used for controlling insects may be divided into two general types known as dormant oils and summer oils, the latter being highly refined products, also called white oils.

Dormant oils.—Dormant oils having a viscosity of from 90 to 150 seconds (Saybolt, at 100° F.) and an unsulfonatable residue of from 50 to 70 percent are emulsified at the rate of 2 to 6 gallons per 100 gallons of water for the control of several fruit insects, such as the

San Jose scale, pear psylla, thistle aphid on prunes, fruit tree leaf roller, aphids, and spider mites.

The oil is sometimes used in combination with dinitro compounds to facilitate control of certain pests, in which case less oil is used.

Dormant oils meeting the above specifications may be purchased from most oil companies and then emulsified. For this purpose bordeaux mixture, calcium caseinate, blood albumin, soybean flour, casein-ammonia, bentonite, or other emulsifiers may be used. Consult your State agricultural college, or county agricultural agent for directions. Dormant oils are also sold in a self-emulsifiable form ready for dilution with water.

White oils.—White or summer oils are used in the control of the codling moth, spider mites, and leafhoppers on apples; scale insects, mealybugs, and the red spider and other mites on various ornamental and flowering plants; and the corn earworm on corn. Though sometimes used alone, they generally are combined with sprays containing lead arsenate, pyrethrum, derris, cube, or nicotine.

For most purposes the light oils of approximately 52 seconds viscosity (Saybolt, 100° F.) are preferred, but light-medium (about 63 seconds viscosity) and medium (about 72 seconds viscosity) are also employed. For controlling the corn earworm on sweet corn a white mineral oil of 100 to 150 seconds viscosity is used with pyrethrum extract. These oils should have not less than 85 percent of unsulfonatable residue, and for use on tender plants they are usually diluted so that the final spray contains from ¼ to 1 percent of oil. On shrubs and evergreens a 2-percent spray may be employed.

White oil sprays act as adhesives, and when combined with arsenicals they interfere with the removal of the poisonous residues. They may also cause injury to foliage and affect the coloration of apples if applied in too large quantities or too frequently. *Oil sprays should not be applied to foliage on which residues from sulfur sprays are present, because severe burning may result.*

Summer oils may be emulsified with the same materials used to emulsify dormant oils, or with nicotine bentonite. They are, however, most commonly sold as miscible or so-called "emulsible" oils containing about 97 percent of oil, or paste-type emulsions containing 70 to 85 percent of oil. These contain emulsifying agents and need only be diluted with water. The manufacturers usually give full instructions on the containers for use against various pests.

The formulas given below have been found effective for use on ornamental plants.

For red spiders:

Derris or cube powder (4 percent of rotenone)	1 tablespoonful.
White oil emulsion (83 percent of oil)	4 teaspoonfuls.
Water	1 gallon.

For mealybugs and scale insects:

Nicotine sulfate solution (40 percent of nicotine)	1½ teaspoonfuls.
White oil emulsion	3 tablespoonfuls.
Water	1 gallon.

For newly hatched scale insects on hardy shrubs and also against lacebugs:

White oil emulsion (83 percent of oil)	1 cupful (or ½ pint).
Soap flakes	1½ cupfuls.
Nicotine sulfate solution	4 teaspoonfuls.
Water	3¼ gallons.

Another spray that may be used against lacebugs on such shrubs as azalea or rhododendron is:

Derris or cube powder (4 percent of rotenone)	5 tablespoonfuls.
White oil emulsion (83 percent of oil)	½ cup.
Water	3 gallons.

Some ornamental plants, including sweet peas, ferns, and orchids, are injured by oil sprays. Other plants may be injured where the spray collects in cavities or leaf axils; as the water evaporates, excess oil is left at these points. Palms and other plants having cavities in which spray material collects should be syringed with water or laid on their side after being sprayed with oils. Certain pyramidal junipers and spruces may also be injured by oil sprays. It is advisable to wash or syringe the more tender plants with water an hour or so after applying the spray.

Although oil emulsion can be prepared at home, it is much more satisfactory for the user of small quantities to purchase the prepared product.

Along with extract of pyrethrum, a white mineral oil or summer oil of 100 to 150 seconds viscosity (Saybolt, at 100° F.) is used to protect sweet corn from injury by the corn earworm. The pyrethrum extract (sometimes called oleoresin of pyrethrum) having a 20-percent pyrethrin content is available on the market. To obtain a 0.2-percent pyrethrin content, which is recommended, 38 ml. (or about 1¼ fluid ounces) of this extract should be added per gallon of oil. Application of about ¼ teaspoonful to each ear is made with a modified force oiler (oil can) or with a medicine dropper, one-half or three-fourths full, according to the size of the ear. Treatment is made immediately after the ears are fertilized, that is, as soon as the silks become wilted but not before about the third day after silk becomes exposed.

NAPHTHALENE

Naphthalene ($C_{10}H_8$), obtained from coal tar, is generally sold as white crystalline flakes or as the well-known "moth balls." Crude naphthalene is sold in flake and chip form and is colored by the impurities present. Naphthalene vaporizes at a noticeable rate at room temperature, but the vapor, although detectable by its tarry odor, is not sufficiently concentrated to produce inflammable mixtures with air.

The use of the refined product in clothes moth control is well known. A less refined material has been used as a soil treatment for wireworm control in irrigated lands of the West and for the control of the carrot rust fly. Consult the State entomologist for information on its use locally for these pests.

Naphthalene in the form of flakes or in solution in certain solvents is also volatilized in greenhouses over lamps for the control of red spiders and thrips on carnations and certain other crops that will tolerate the fumes. The fumigations are carried out on cloudy days or at night at a temperature near 80° F. and with high humidity. From 2 to 3 ounces are used per 1,000 cubic feet of space, and the lamps are adjusted to volatilize the flakes evenly over a period of about 6 hours. The margin of safety between a dosage tolerated by plants and one toxic to insects is very narrow, therefore it should not be used in greenhouses except by experienced workers.

The flakes are mixed with soil to destroy wireworms, white grubs, the garden centipede, and other pests at the rate of 500 pounds per acre or 19 ounces distributed under 100 linear feet of 12-inch furrow slice. They are also scattered in places frequented by sowbugs, millipedes, and slugs.

When mixed with dormant gladiolus corms in storage at the rate of 1 handful per 100 corms or 1 pound per 2,000 corms, it destroys the gladiolus thrips. It should be used only in the fall, after harvest. Late spring treatments may injure the corms.

Caution.—Persons breathing naphthalene vapors for several hours will experience irritation of the respiratory tracts and eyes. High concentrations can cause the same discomfort in a very short time.

NICOTINE

Nicotine ($C_{10}H_{14}N_2$) is an alkaloid which occurs in tobacco and related plants. In its pure state it is an oily, colorless liquid which is soluble in water, alcohol, and fatty oils. For spraying purposes it is commonly sold in the form of solutions of nicotine sulfate. The standard brands on the market usually contain the equivalent of 40 percent of nicotine. They are deep-brown, thick liquids and are very stable. Nicotine sulfate is a byproduct of the tobacco industry in the United States and normally is readily available.

Nicotine is used as a contact insecticide, a stomach poison, or a fumigant. As a contact spray nicotine sulfate (40 percent nicotine) is used at the rate of 1 to 2 pints per 100 gallons of water or other sprays, to which may be added 2 to 4 pounds of soap. Nicotine sulfate is compatible with bordeaux mixture, lime-sulfur, or other alkaline materials.

Nicotine combinations are effective against aphids, the pear psylla, grape leafhoppers, adult whiteflies, rose slugs, certain leaf miners, the young stages of plant bugs, mealybugs, and scale insects.

The combination of nicotine sulfate and mineral oil is effective as a stomach poison, contact spray, and ovicide and is used against the codling moth. A more effective codling moth spray is the combination of nicotine sulfate and bentonite. See Nicotine Bentonite (p. 24).

A spray used for control of the boxwood leaf miner during the adult emergence period is made up as follows:

	For small quantities	*For large quantities*
Nicotine sulfate	1 teaspoonful.	1½ pints.
Molasses	1 pint.	12 gallons.
Water	7 pints.	88 gallons.

The material is applied to both surfaces of the leaves as a fine spray. It kills the adults as they emerge from the leaves and entangles others in the sticky deposit.

Nicotine may also be incorporated in dusts (see p. 25). Nicotine fumes are used extensively as a greenhouse fumigant and for controlling aphids on peas, cabbage, beans, and other crops.

Caution.—Nicotine and its compounds are violent poisons, and care should be exercised in their use. Exposure to fumes or sprays for any length of time causes the development of acute nausea in some persons. Combinations other than nicotine ben-

tonite are most likely to give this effect. Those who experience difficulty of this kind should protect themselves by the use of a respirator provided with pads saturated with a solution of citric acid.

Very acute illness can be caused by the absorption of nicotine through the skin. If concentrated solutions of nicotine are spilled on the skin, they should be immediately washed off with water. The operator should not continue working in outer clothing which has become wet with nicotine-containing sprays, as the body will take up the nicotine from the clothing.

NICOTINE BENTONITE

Bentonite has the property of combining with nicotine to form a compound more resistant to weathering than other nicotine preparations, and this compound has been used extensively on apples during the past few years as a substitute for lead arsenate in the control of the codling moth, and to some extent on grapes for the control of the grape berry moth.

Nicotine when combined with bentonite may persist on fruit for 2 or 3 months, though in amounts too small to be toxic to man.

Tank mixtures are the cheapest and most effective but are more adhesive and may leave visible bentonite residues at harvest.

An effective tank-mixed spray for use on apples during the cover spray period consists of—

Nicotine sulfate (40 percent)	1 pint.
Wyoming bentonite	5 pounds.
Crude raw soybean oil	1 quart.
Water	100 gallons.

Place about one-third of the water in the tank, add the nicotine sulfate, then add the bentonite slowly with strong agitation, followed by the soybean oil and the remainder of the water. Continue the agitation while spraying.

An equally effective tank-mix nicotine bentonite, recently developed, which leaves a much less conspicuous residue than the above formula, may be prepared by substituting 8 pounds of Mississippi bentonite for the Wyoming bentonite. If the Mississippi bentonite is used, 2 quarts of a summer spray oil (see Mineral Oil, p. 20) may be substituted for the soybean oil when cheaper or more readily available.

Proprietary nicotine bentonites are obtainable on the market.

NICOTINE DECOCTIONS (HOME-MADE)

For many years gardeners have used tobacco decoctions prepared in different ways. The most common method is to soak tobacco stems or high-grade tobacco refuse for 24 hours, stir occasionally, and use the liquid. It requires 1 pound of stems for each gallon of water to make a satisfactory spray. If high-grade refuse is used, less is required—in some instances only one-fifth to one-tenth as much refuse as stems. The ready availability of commercially prepared nicotine extracts has rendered this method of obtaining nicotine almost obsolete; see Nicotine, page 23.

Tobacco stems are burned in greenhouses to produce smudges to kill aphids and whiteflies, but this method is not used very much nowadays.

NICOTINE DUSTS

Nicotine dust is the name commonly used to designate a dust made by combining nicotine with a powdered carrier (*see* Diluents or Carriers, p. 11). Ground tobacco, which also contains nicotine, is usually called tobacco dust; see page 37. The former has the advantage that a higher percentage of nicotine may be incorporated in the dust and the nicotine is more volatile and effective. Also, the nicotine dust is composed of finer particles, unless the tobacco dust is very finely ground.

For small plantings, nicotine dust may be prepared with an ordinary flour sifter, using 1 pound of hydrated lime and 1 to 1½ ounces of 40-percent nicotine sulfate solution. Or, place a quart of fresh hydrated lime in a container which can be tightly closed. Then add a handful of small stones or marbles, pour in 1 fluid ounce of nicotine sulfate, close the lid, and shake well for several minutes. To prepare larger quantities, roll the ingredients together in a drum or keg for at least 20 minutes with a peck of stones the size of goose eggs. Until used, the nicotine dust must be preserved in tight metal or glass containers, as it loses its strength very rapidly when exposed to the air.

Nicotine dust is used against aphids, such as occur on pea, cabbage, melon, turnip, and other plants, as well as against the striped cucumber beetle, adults of the greenhouse leaf tier, adults of the boxwood leaf miner, and the orchid fly.

For greater effectiveness, nicotine dusts should be applied to dry foliage when the temperature is above 65° F. and the air is still. Apply thoroughly to reach all insects present and repeat the treatment if control is not complete. For the boxwood leaf miner, make applications daily throughout the period of adult emergence.

NICOTINE FOR FUMIGATION

Nicotine for fumigating purposes is derived from several sources. The burning of tobacco stems is one of the oldest methods, but is now being discarded because of the difficulties surrounding their use. At present fumigating with nicotine is done almost entirely by the burning of commercially prepared nicotine powders available in especially devised pressure cans, or by vaporizing liquids containing free or volatile nicotine from the heating pipes. The pressure-can method may be used to fumigate a few individual plants, a single bench, or an entire greenhouse.

When free nicotine is to be evaporated on the steam pipes, it should be painted on the pipes while they are cool, after which the steam is turned into the pipes to drive off the nicotine vapors or fumes. The usual dosage ranges from 1 fluid ounce to 2,000 cubic feet of space in older houses to 1 fluid ounce to 4,000 cubic feet in newer or tight houses. The exposure is usually for overnight.

Fumigation of plants with nicotine should be done on still nights and after sunset, and under dry conditions at temperatures between 50° and 70° F. Violets and certain ferns are often injured by nicotine fumigation.

Detailed directions on the dosage and procedure to be followed are usually given on the labels of the containers in which these materials are purchased.

Vaporized nicotine is also used to a limited extent for the control of aphids on peas and cole crops. The method consists of injecting a

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concentrated nicotine preparation (containing 80 percent of free nicotine) into the exhaust pipe of a gasoline engine while the engine is running at a comparatively high speed. The vaporized nicotine produced is blown out through a boom at the rear of the engine and expelled under a gas-proof cloth, or trailer. This cloth trailer is 100 feet long and is drawn over the field at the rate of 100 feet per minute.

Caution.—Liquid nicotine and its vapor are both poisonous, and great care should be exercised in handling.

OIL DUSTS

Oil dusts usually contain about 2 to 5 percent of lubricating oil of 80 to 110 seconds viscosity (Saybolt, 100° F.) and may include various insecticides or fungicides. The oil is added to improve the adhesive properties of the dust.

An oil dust which may be used for control of the oriental fruit moth and brown rot on peach consists of 60 pounds of dusting sulfur, 35 pounds of dusting talc, and 5 pounds of lubricating oil. This should be applied at weekly intervals for a period of 4 to 5 weeks before harvest. It has little or no toxicity to the insect but acts as a mechanical barrier and irritant.

A mixture which has been used for the plum curculio on peach consists of 30 pounds of dusting sulfur, 30 pounds of dusting talc, 25 pounds of hydrated lime, 10 pounds of lead arsenate, and 5 pounds of lubricating oil.

Oil dusts containing pulverized rotenone-bearing roots are used to control the pea aphid.

Oil dusts may be prepared in the same manner as nicotine dusts. Thorough mixing to break up lumps is necessary.

PARADICHLOROBENZENE

Paradichlorobenzene ($C_6H_4Cl_2$), known to the trade as P. D. B., is a white, crystalline compound. It volatilizes slowly at 80° F., has a distinctive odor, and the vapor formed is noninflammable and penetrating.

Paradichlorobenzene is employed to a limited extent as a soil fumigant to kill various insect pests, such as root aphids, wireworms, and the sweetpotato weevil. Its principal use as an insecticide, however, is for the control of the peachtree borer. The crystals are spread in a circle around the base of the peach tree about 1 to 1½ inches from the trunk and then covered with a mound of soil. This is done in the early fall or spring at rates varying from ¼ to 2 ounces per tree, depending upon age. A solution in cottonseed oil is also applied as a paint in the control of the lesser peach borer. An effective mixture consists of 1 pound of paradichlorobenzene dissolved in 2 quarts of cottonseed oil. It is sometimes necessary to warm the cottonseed oil to room temperatures to aid in dissolving the paradichlorobenzene. Apply only to well-defined infested areas of the trunks or limbs.

Paradichlorobenzene crystals, at the rate of 1 pound per 100 square feet, are spaded into greenhouse soils for the control of the garden centipede. This treatment must be applied 3 weeks before replanting the beds.

Caution.—Paradichlorobenzene should be stored in airtight containers to avoid loss by evaporation. Do not expose foodstuffs to the vapor of this chemical, as they absorb it and are then unfit for consumption because of a pronounced odor or taste.

PARIS GREEN

Paris green is known chemically as copper acetoarsenite ($Cu(C_2H_3O_2)_2.3Cu(AsO_2)_2$). It was one of the first stomach poisons used in America for the destruction of leaf-eating insects. This material is a very poisonous, heavy, emerald-green powder, which for use as an insecticide should be finely ground, and should contain not less than 50 percent of total arsenious oxide and not more than 3½ percent of water-soluble arsenious oxide. It is prepared and used both as a spray and as a dust for the control of chewing insects and in poisoned baits (see p. 28).

Paris green is highly toxic to most insects but is also toxic to many plants and is rarely used on fruit trees. If used as a spray, constant agitation is necessary to keep it in suspension. One of its chief uses as a spray is for the control of the Colorado potato beetle, combined with bordeaux mixture.

For a spray use the following formula:

	For small quantities	*For larger quantities*
Paris green	2 teaspoonfuls.	2 pounds.
Hydrated lime	4 tablespoonfuls.	8 pounds.
Water	1 gallon.	100 gallons.

The lime is added to the spray to combine with the soluble arsenic in the paris green and thus reduce plant injury.

As a dust it is mixed with a carrier such as lime and is used for the control of cabbage caterpillars before the cabbage head begins to form. It is also used on tobacco in some areas to control hornworms and flea beetles.

Before the development of the tartar emetic and brown sugar combination for the control of the gladiolus thrips, paris green was recommended and used for this pest; however, some foliage injury usually followed such use.

To prepare a spray for gladiolus thrips use:

	For small quantities	*For larger quantities*
Paris green	1 tablespoonful.	4 pounds.
Brown sugar	2½ cups.	66 pounds.
Water	1 gallon.	100 gallons.

To obtain best results with this spray, use a nozzle that produces a fine mist and apply only enough to form small droplets on the foliage. If more is applied, the droplets coalesce and run to the base of the plant, causing waste and plant injury.

Caution.—Paris green is extremely poisonous and therefore should be kept in a safe place, away from foods. Tight containers plainly labeled and marked "Poison" should be used for storing the material. Paris green or its dust mixtures should not be inhaled. The skin, and especially open wounds, should be protected from this compound, or serious poisoning may result.

PHENOTHIAZINE

Phenothiazine ($C_6H_4NHC_6H_4S$) is one of the new organic stomach poisons. Its use in veterinary medicine has eclipsed its status as a plant insecticide, but more work needs to be done on its insecticidal

possibilities. It is a light-brown, or sometimes green, crystalline chemical, which may be used for the control of the Mexican bean beetle and has also given promising results for the control of the codling moth and certain apple diseases, used at the rate of 2 to 4 pounds per 100 gallons of spray. It has some possible use against mosquito larvae when diluted with acetone. Also it has given promising results in North Dakota, used as a dust to control the short-nosed cattle louse and the long-nosed cattle louse.

It has the advantage of being relatively nonpoisonous to higher animals, but it may affect the skin of those handling it.

PHOSPHORUS PASTE

Commercial phosphorus pastes are prepared from yellow phosphorus. Essentially these pastes are made by grinding the yellow phosphorus in the presence of water and then mixing with flour in the proper proportion. Glycerine is sometimes used as an ingredient. Commercial preparations usually contain from 1 to 2 percent of phosphorus.

Prepared phosphorus paste may be placed on edges of benches or in other places frequented by roaches in greenhouses. It has been recommended for use against the Surinam roach.

Caution.—Because of its very poisonous nature, phosphorus should be handled with great care. The effects are cumulative, and for this reason phosphorus is more dangerous than some of the more acutely poisonous substances. Since yellow phosphorus is so poisonous and also highly inflammable, it is safer to purchase the commercial paste than to attempt to prepare it.

The prepared paste is sold in containers of various sizes.

POISONED BAITS

White arsenic (arsenious oxide), sodium arsenite, sodium fluosilicate, or paris green may be used in making poisoned baits of various types. These materials are discussed separately in this publication.

One of the commonest baits is poisoned-bran mash. Bran is a well-known byproduct of the wheat milling industry. It is used in making poisoned bait for the control of cutworms, grasshoppers, crickets, green June beetle grubs, roaches in plant houses, ants, millipedes, sowbugs, and slugs. A commonly used formula is as follows:

	For small quantities	*For large quantities*
Bran	1 quart.	100 pounds.
Arsenical[1] (see above)	2 teaspoonfuls.	4 pounds.
Cheap molasses[2]	4 tablespoonfuls.	1 gallon.
Water	1 pint.	7 to 10 gallons.

[1] Sodium arsenite solution (32 percent As_2O_3) is used at the rate of 2 quarts per 100 pounds of bran. Recent results have shown that sodium fluosilicate may be substituted for the arsenical in this formula and used for the control of grasshoppers, Mormon cricket, armyworms, and cutworms. It can probably be used to control the other pests mentioned herein. It should be used instead of an arsenical in bait for the Mormon cricket.

[2] Evidence accumulated to date does not show that molasses adds to the attractiveness or effectiveness of the bait, and it may be left out of it without loss.

The bran and arsenical are thoroughly mixed, and the water, containing the molasses, is then carefully stirred in. Enough water is used to make the bait thoroughly wet but not enough to drip when squeezed. To control cutworms, it is scattered near the plants in the evening. To control grasshoppers, it is scattered early in the morning. The above formula for small quantities of bait (using 1

quart of bran) is adequate for treating a garden 50 feet by 50 feet in size. By broadcasting thinly and evenly, pets and birds will be unable to gather up enough of the material to be poisoned. Any particles of the material which adhere to tender plants should be dislodged to avoid injury.

On soil which has been in sod or which was weedy the previous season, it is well to apply poisoned bait as insurance against cutworms, especially before setting out plants or before the plants appear above ground.

To make a poisoned bait for ants, sowbugs, and millipedes, mix 1 part (by volume) of paris green with 9 parts of sugar and sprinkle the bait over the soil. Avoid sprinkling it on tender foliage, otherwise severe burning may result.

An effective poisoned bait to control mole crickets is prepared by mixing—

	For small quantities	*For large quantities*
Wheat bran	12.5 pounds.	100 pounds.
Sodium fluosilicate	1 pound.	8 pounds.
Water	to moisten.	to moisten.

Apply at the rate of 20 pounds per acre.

Caution.—These baits are poisonous and must be stored in labeled containers so that they will not be used for human or animal consumption.

Bran is usually available locally at feed stores or mills. Some feed stores sell prepared poisoned baits.

PYRETHRUM, OR INSECT POWDER [1]

One of our oldest insecticides and one of the most generally useful is pyrethrum. Pyrethrum powder is a plant product and is obtained by grinding the flower buds of the plant *Pyrethrum cinerariaefolium*, a plant which belongs to the same botanical family as chrysanthemums. The source was originally Persia and Dalmatia, and more recently Japan, but now Kenya Colony, Africa, supplies pyrethrum to this country and our allies. The toxic ingredients of the flowers are the pyrethrins I and II, which together occur in Kenya flowers to an average of about 1.3 percent. In the country of origin the unopened flower buds are harvested, dried, and baled for export. In the United States the flowers are ground and used for making extracts containing the toxic principles, or are ground fine and used as powder.

Pyrethrum loses part of its toxic ingredients in a few days when exposed to air and light. Even in airtight metal containers there is some loss of pyrethrins after several months.

Pyrethrum has several distinct advantages; it is comparatively harmless to higher animals, and in dosage sufficient to kill insects leaves no poisonous residue. It is principally a contact insecticide, and one of its chief disadvantages is the lack of residual effect, i. e., only insects touched with it are killed. For this reason pyrethrum has not proved satisfactory for use against the most important fruit insects, particularly where the period of attack may extend over several months.

[1] Wartime conditions have led to certain restrictions on the use of pyrethrum insecticides, and these restrictions are subject to change dependent upon the supply. For up-to-date information on the subject consult the War Food Administration, Chemicals and Fertilizers Branch, Chemicals Division, Washington 25, D. C.

Pyrethrum is used principally against houseflies, mosquitoes, cockroaches, body lice, leaf tiers, plant bugs, leafhoppers, mushroom flies, the imported cabbageworm, the cabbage looper, and the corn earworm.

Pyrethrum is used in both dusts and sprays. One formula for a dust for the control of the potato leafhopper on bean is made up as follows:

	For small quantities	*For large quantities*
Pyrethrum powder (1.3 percent pyrethrins)	5 tablespoonfuls.	4 pounds.
Sulfur	5 cups.	96 pounds.

Manufactured dusts which generally contain from 0.1 to 0.3 percent of pyrethrins may be purchased for use by the home gardener. The dust containing 0.3 percent of pyrethrins is recommended for general purposes.

When used as a spray, pyrethrum is generally applied as a diluted extract. The pyrethrins and resins are extracted with a solvent and mixed with emulsifying agents for use with water on plants, or with light kerosene for use as fly sprays in buildings, or with oil emulsions for a mosquito larvicide. Moderately concentrated pyrethrum extracts (containing 2 to 3 percent of pyrethrins) properly prepared and packaged do not deteriorate rapidly. Such various concoctions should be used in accordance with the manufacturer's recommendations.

A highly refined white mineral oil of from 100 to 150 seconds Saybolt viscosity at 100° F., containing 0.2 percent of pyrethrins, is used for injection into the silk masses of sweet-corn ears to prevent their becoming infested by the corn earworm. Oleoresin of pyrethrum should be used in preparing this insecticide, and not pyrethrum extracts containing highly refined kerosene or other solvents likely to impart an undesirable odor or flavor to the corn. About a 20-drop dose of the prepared oil is injected into the basal portion of the silk mass of each ear after the silks have begun to wilt and all danger of interference with fertilization is past. A force oil can or, in the case of small garden plantings, a medicine dropper is used for this purpose.

Caution.—Although the danger from human consumption of traces of pyrethrum is not great, persons allergic to ragweed in some instances are subject to attacks of hay fever when exposed to pyrethrum.

ROTENONE-CONTAINING ROOTS [2]

Rotenone-containing insecticides are prepared from the roots of certain tropical and semitropical plants which, in addition to rotenone, usually contain other toxic ingredients, including toxicarol, deguelin, tephrosin, sumatrol, and a few others. Rotenone, $C_{23}H_{22}O_6$, is considered the most important. The plants from which these toxic substances are derived include species of *Derris* (principally *elliptica*), which are grown extensively in Malaya and the East Indies, and species of *Lonchocarpus* (*nicou* and *urucu*), of South America. Experience indicates that usually there is little difference between the various roots, provided they are of equal rotenone content. The rotenone content is usually 4 to 5 percent, and there is

[2] Wartime conditions have led to certain restrictions on the use of rotenone insecticides, and these restrictions are subject to change dependent upon the supply. For up-to-date information on the subject consult the War Food Administration, Chemicals and Fertilizers Branch, Chemicals Division, Washington 25, D. C.

present about 2½ to 3 times as much of other extractives. Rotenone, in addition to being toxic to many insects, is also poisonous to fish but is not harmful to warm-blooded animals when eaten in small amounts. Therefore, the use of ground roots is permissible on leafy vegetables which are consumed by man or domestic animals.

The roots are usually ground sufficiently fine so that most of the powder will pass through a number 200 screen. The powder is diluted to give a very small amount of rotenone in the mixture to be applied. It may be stirred into water and applied as a spray or mixed with some fine dust for treating infested plants. For sprays the final rotenone content may range from as low as 0.005 to 0.025 percent or higher, and for dusts from 0.5 to 1.0 percent or higher.

Liquid extracts containing the active ingredients are also available, but certain of these may lose some of their effectiveness when mixed with water. The derris and cube insecticides are sold under various trade names; but since the strength of the active ingredients may vary in the different brands, they should be used as directed by the manufacturer.

The more important uses, on vegetables, flowers, and fruits, of rotenone root powder are to control the Mexican bean beetle, cabbage caterpillars, cucumber beetles, the pea aphid, the pea weevil, the asparagus beetle, flea beetles, the cherry fruitfly, the imported currant worm, rose slugs, the Japanese beetle, spittle bugs on strawberries, raspberry fruitworms, and the European corn borer.

Dusts and sprays are mixed on the basis of rotenone content. A dust usually should contain at least 0.5 percent. To mix a 0.5-percent dust, use 12½ pounds of the rotenone root powder containing 4 percent of rotenone and 87½ pounds of talc, sulfur, or other diluent. If the root powder contains 5 percent of rotenone, use 10 pounds of it and 90 pounds of the diluent. For smaller quantities, weigh by ounces instead of pounds.

To prepare a spray for bean beetle control, use 3¼ pounds of rotenone root which contains 4 percent of rotenone, or 2½ pounds of rotenone root which contains 5 percent of rotenone, to 100 gallons of water. For smaller quantities use 1 ounce of 4-percent powder to 2 gallons or 1 ounce of 5-percent powder to 2½ gallons. This mixture will contain approximately 0.015 percent of rotenone.

A spray mixture consisting of derris powder, pyrethrum extract, and sulfonated castor oil with water has been found effective against red spiders, thrips (except the gladiolus thrips) on certain flowering plants, the cyclamen mite on chrysanthemums, aphids, cucumber beetles, tarnished plant bugs, certain species of leaf rollers, and leaf tiers. The spray is made up according to the following formula:

	For small quantities	*For large quantities*
Rotenone-containing root powder (containing 4 percent of rotenone)	1 tablesponful.	1 pound.
Pyrethrum extract (alcoholic extract, containing 2 percent of pyrethrins)	4 teaspoonfuls.	2 quarts.
Sulfonated castor oil	2 teaspoonfuls.	1 quart.
Water	1 gallon.	100 gallons.

In preparing this spray, add the sulfonated castor oil to the water. Next add a small quantity of this oil-and-water mixture to the derris or cube powder to make a uniform paste. Then stir the paste slowly into the remainder of the oil-and-water mixture. Finally add the pyrethrum extract to this mixture in case it is intended for the control of thrips or the cyclamen mite. For either red spiders or whiteflies, the pyrethrum may be omitted. A proprietary spreader-sticker, such as sodium oleyl sulfate plus synthetic resinous base, may be substituted for the sulfonated castor oil in the above formula, since the oil may at times injure the petals of open flowers and also the foliage of some plants. This material is used at the rate of ¾ teaspoonful per gallon, or 1½ pints per 100 gallons, of spray mixture.

For the control of the European corn borer on market or home-garden sweet corn a spray is preferable to a dust. In mixing the spray, 4 pounds of the ground root (containing not less than 4 percent of rotenone) are used per 100 gallons of water, plus a suitable spreading agent, either sodium monosulfonate of butylphenylphenol or aromatic monosodium sulfonate. Rotenone-bearing powders containing the proper quantity of suitable spreading agent may sometimes be found on the market. The spreading agent facilitates the penetration of the spray deep into the whorl and between the leaf sheaths and the stalk where the larvae feed. Thorough wetting of these areas is necessary to insure reaching the young borers. As there is danger of injuring corn by using too much spreader, the quantity of this should be carefully regulated. To prepare the spreading agent for mixing with a spray, dissolve 1 pound of the spreader in 2 quarts of water and then add enough water to make 3 quarts (96 ounces) of solution. This makes a stock solution of the spreader sufficient for 300 gallons of spray.

A number of commercial preparations containing extracts of derris or cube, with various spreaders added, are now available and are ready for dilution with water.

Derris or cube extracts should be kept in closed containers, and sprays should be applied immediately after their preparation. These sprays lose their effectiveness within a comparatively short time after they are applied to plants.

Properly packaged and stored ground roots containing rotenone do not deteriorate appreciably for several years, nor does any deterioration occur when they are diluted with inert carriers like pyrophyllite, neutral talc, or powdered plant products and placed in closed containers in a dark, dry room.

Caution.—Ground rotenone-bearing roots irritate the tender skin and the mucous membranes.

SOAP SPRAYS

Sprays made from soap are very useful, especially for small plantings or house plants. Dissolve a cubic inch of ordinary soap or 2 tablespoonfuls of soap flakes in 1 quart of water. If fish-oil soap is at hand, a rounded tablespoonful may be used. Soap sprays are useful against

aphids and the younger stages of mealybugs, scale insects, whiteflies, and other soft-bodied insects, but should not be used on very young or tender plants. For use on hardy plants the amount of soap may be increased to kill larger insects.

The soapy water remaining in the tub after clothes have been laundered may also be used for spraying or dipping foliage of infested house plants. When potted plants are dipped, they should be inverted and submerged only to the soil surface and then laid on their sides to drain before being set in an upright position. This will avoid saturating the soil with the soap solution. House plants dipped or sprayed with concentrated soap solutions should not be placed in full sun for 24 hours, after which the foliage may be syringed with clear water and the plants returned to their former locations.

Soap is used as a wetting and spreading agent with nicotine, pyrethrum, and some other sprays. The amount of soap required in a spray mixture is regulated somewhat by water hardness. If used with lead arsenate, some soaps may increase arsenical injury to foliage.

Oleates of monoethanolamine, triethanolamine, and ammonia, as well as several other soaps, have been used with mineral oil and lead arsenate in making deposit-building mixtures to obtain the heavy deposits of lead arsenate often needed for control of the codling moth.

SODIUM ARSENITE

Sodium arsenite (essentially $NaAsO_2$), a white crystalline solid, is soluble in water and is, therefore, unsuitable for use on living plants. In fact, it is probably best known as a weed killer. It is more generally available in liquid form containing about 32 percent of arsenic trioxide (As_2O_3), although it can also be purchased as a powder. Its chief use in direct control of insects is in poisoned baits (p. 28), but it is used as a spray on wild vegetation to control grasshoppers.

Caution.—Sodium arsenite is a violent poison and must be stored in clearly labeled packages.

SODIUM CYANIDE

Sodium cyanide (NaCN) is a white, deliquescent, very poisonous salt manufactured in this country. When it is mixed with dilute sulfuric acid a reaction takes place in which the deadly hydrocyanic acid gas (HCN) is liberated. For fumigation purposes sodium cyanide should be practically free from chloride and contain not less than 51 percent of the cyanogen radical. The chemical may be purchased in the form of "eggs," each weighing ½ or 1 ounce. Dosages may, therefore, be easily calculated by counting the number of eggs required.

Hydrocyanic acid gas is used as a fumigant to control such pests as scale insects, aphids, whiteflies, mealybugs, and thrips on plants and bulbs in fumigation vaults, greenhouses, or tents. The dosages range from ⅛ to 1 ounce of sodium cyanide per 1,000 cubic feet of space, with exposure periods of 1 to 5 hours or overnight. The dosage and length of exposure depend upon the plants' tolerance to the gas.

Plant tissue of all kinds is very susceptible to the action of this gas, and the margin of safety between dosages which will kill the insect and the plant is very narrow. The materials are generally combined in the proportion of 1 ounce of sodium cyanide, 1½ fluid ounces of sulfuric acid, and 3 fluid ounces of water.

Plant materials are fumigated in darkness and afterward protected for a short period from light to avoid plant injury.

In certain instances growing plants may be fumigated under canvas tents placed over them. For example, the boxwood leaf miner may be controlled by this method, sodium cyanide being used at the rate of 2 ounces per 100 cubic feet of space, with 3 fluid ounces of sulfuric acid and 6 ounces of water, for a period of 1 hour. The plants must be dormant and dry, and the temperature must not be too high—usually 40° to 55° F.

Caution.—In carrying out a fumigation a definite procedure and certain precautions must be followed. Sodium cyanide should, therefore, be used only by experienced fumigators thoroughly familiar with the methods of handling it and the hazards involved.

Hydrocyanic acid gas is colorless and is one of the most deadly poisonous gases known. In case of accidental inhalation of the gas, the person affected should be kept in the open air and not allowed to exert himself. Inhalation of ammonia vapor may be of some help.

All forms of cyanide are extremely poisonous and should be plainly labeled and kept in a safe place. To avoid deterioration, store the material in tight containers.

SODIUM FLUORIDE

Sodium fluoride (NaF) is a white, very poisonous powder, soluble in water. The commercial product and commonly employed grade of powder is 94 to 97 percent pure.

Sodium fluoride, undiluted, when dusted in the areas frequented by ants and roaches, except the Surinam roach, will gradually eliminate them. Sodium fluoride should not be used on plants.

Caution.—Since sodium fluoride is poisonous if taken internally, it should be kept in tight containers plainly marked "Poison" and stored in a dry, safe place away from foods. If the dust is inhaled, it is somewhat irritating to the respiratory passages.

In New York City all sodium fluoride must be colored blue, and the National Association of Insecticide and Disinfectant Manufacturers, Inc., has gone on record favoring this practice throughout the United States. This coloring is done to denote its poisonous nature.

SODIUM FLUOSILICATE

Sodium fluosilicate (Na_2SiF_6), or sodium silicofluoride, resembles sodium fluoride and is sometimes used undiluted as a substitute for it against roaches. Sodium fluosilicate will injure plants unless used in

very dilute form. It is used chiefly as a poison in cutworm, mole cricket, or grasshopper bait.

Caution.—Sodium fluosilicate is a strong poison and should be kept away from food.

SULFUR

Sulfur (S), a native element, is an important fungicide and insecticide, as well as a useful adjunct or carrier in many dust mixtures. It comes in several forms for insecticidal uses—as a finely ground powder; as a powder plus a wetting agent, called wetable sulfur; and as flotation paste (*see also* Liquid Lime-Sulfur and Dry Lime-Sulfur, p. 17). Much progress has been made in grinding sulfur, so now it is almost universally available in such fineness that almost all of it will pass through a number 325 sieve. The most finely divided material available at low cost is the flotation sulfur paste, which is almost colloidal and sticks well to foliage. Sulfur is used for the control of the potato leafhopper (on bean, aster, and dahlia), the cotton flea hopper, the tomato psyllid, red spiders, the phlox plant bug, the tarnished plant bug, and the broad mite. As a diluent for dusts it is often used with lead arsenate, pyrethrum powder, ground rotenone-containing roots, or other materials. (*See* Oil Dusts, p. 26.) A fungicide-insecticide dust to control black spot and rose slugs on roses comprises lead arsenate 1 pound, tobacco dust 1 pound, and sulfur 8 pounds. Flowers of sulfur prepared by sublimation, being too coarse, are not used for dusting plants but may be used by burning to fumigate mushroom houses and greenhouses between crops.

When sulfur is used on fruit trees it should not be followed by oil sprays before all sulfur residues have disappeared. Oil and sulfur may cause severe foliage injury.

Caution.—In using sulfur, especially when applying or handling it as a dust, care should be taken to prevent getting it into the eyes. If the eyes are affected, do not rub them. It is well to wear goggles and a respirator.

STYRENE DIBROMIDE

Styrene dibromide is a colorless, crystalline chemical having a mild naphthalenelike odor. It is soluble in and imparts no color to mineral oil and may be used, at the rate of 1 gram dissolved in 100 cubic centimeters of highly refined white mineral oil, as a satisfactory substitute for pyrethrins in corn earworm oil. (See Pyrethrum, or Insect Powder, pp. 29–30.)

TAR DISTILLATE

Coal-tar distillates, commonly called tar oils, have been used as dormant sprays for the control of aphids, the eye-spotted budmoth, and the oystershell scale on apple. These preparations are emulsified so they can be mixed with water. They are also sometimes sold in combination with dormant mineral oil.

Since they must be combined with mineral oil for the control of the San Jose scale, **are caustic to the skin of spray men,** and are likely

to cause injury to the trees, tar-oil sprays have been displaced to some extent by oil solutions of the dinitro organic compounds (see p. 12).

TARTAR EMETIC

Tartar emetic is known chemically as potassium antimonyl tartrate ($K(SbO)C_4H_4O_6.\frac{1}{2}H_2O$). It is manufactured by combining antimony oxide with tartaric acid, the latter being obtained from a by-product of the wine industry. As marketed for insecticidal purposes (technical grade) it is a white powder which is soluble in water.

One of the insecticidal uses of this material is in ant poisons. Its most extensive use is in a spray for the control of the citrus thrips, the gladiolus thrips, and common red spiders. It has also been used against the onion thrips.

A spray solution for control of the gladiolus thrips on gladiolus, the flower thrips on roses, the orchid thrips on orchids, the chrysanthemum thrips, the banded greenhouse thrips, and the onion thrips on various ornamentals is made up as follows:

	For small quantities	*For large quantities*
Tartar emetic	2 teaspoonfuls.	2 pounds.
Brown (or white) sugar	3 tablespoonfuls.	4 pounds.
Water	1 gallon.	100 gallons.

Dissolve each in a small quantity of water, then dilute to the quantity desired. Dissolving the tartar emetic may be hastened by using hot water. After this spray solution has been made up, no agitation is required to maintain a uniform spray.

Apply this spray as a fine mist to infested foliage of gladiolus or other plants or to flowers of roses or other plants when infested. The spray should cover the plant parts as tiny droplets. Do not apply so much spray that these droplets will unite and run off. Applications are made weekly, and if rain falls within 24 hours after the spray has been applied the treatment is repeated.

Caution.—Tartar emetic is very poisonous and must be stored away from food products in plainly marked containers. To date a warning color, such as is used in arsenicals and some fluorides, has not been added to tartar emetic.

THIOCYANATES (ORGANIC)

At least three organic thiocyanates, synthetic products made in the United States, are used as plant sprays. They are sold in liquid form; one is chemically beta-beta′-butoxythiocyanodiethyl ether, another is lauryl thiocyanate, a third is a mixture of fenchyl and bornyl thiocyanoacetates. They are chiefly substitutes for pyrethrum sprays and other contact insecticides for use against red spiders on certain plants, especially under glass, and also against the cylamen mite, mealybugs, aphids, scale insects, and thrips. Since thiocyanate sprays injure some plants, they should be used only as recommended by the maker.

Caution.—These compounds are generally considered harmless to man, although some of them are capable of causing dermatitis to humans. Since the hazards are not fully understood, care should be exercised in handling these materials.

TIMBO

See Rotenone-Containing Roots (pp. 30–32).

TOBACCO DUST

Tobacco dust is finely ground tobacco refuse and is a native product. Fresh tobacco dust containing at least 1 percent of nicotine is applied as a mulch on the soil surface about rose plants to destroy larvae of the rose midge as they drop to the ground to pupate in the soil. This material, as a surface mulch or worked into the top inch layer of soil, is also a remedy for the larvae of fungus gnats and for root aphids. It is sometimes used undiluted as a dust to control thrips and aphids on various plants. Tobacco dust is also used as a diluent for pyrethrum powder, rotenone root powder, and other insecticidal dusts.

VEGETABLE OILS

Vegetable oils are used as insecticides or with them in a number of ways. Emulsifiers for mineral oil have been made from olive oil, castor oil, and corn oil. Cottonseed oil is used with paradichlorobenzene for the control of the lesser peach borer. Linseed oil and crude soybean oil have been used as adhesives for lead arsenate or nicotine bentonite sprays applied to fruit trees. These oils are also partially effective against the eggs of the codling moth and certain other insects.

Peanut oil or soybean oil is used (1 or 2 percent) in the preparation of dusts containing derris or cube for the control of the pea aphid.

Sulfonated castor oil, commercially known as Turkey-red oil, is a viscous, transparent light-yellow liquid. It is one of the wetting and emulsifying agents used in the preparation of various sprays. In a derris-pyrethrum spray used for the control of red spiders and thrips on greenhouse and garden plants, it is added at the rate of 1 part to 300 or 400 parts of the spray.

WETTING OR SPREADING AGENTS

In addition to soap, which is discussed on page 33, many other materials are used as wetting and emulsifying agents. Sold under various trade names, some of them are chemically known as—sodium monosulfonate of monobutyldiphenyl, sodium oleyl sulfate, sodium lauryl sulfate, sulfonated vegetable oils (see Vegetable Oils, p. 37), sodium salt of an alkyl naphthalene sulfonic acid, and sodium lauryl sulfate paste.

Sodium monosulfonate of monobutyldiphenyl is a fine tan-colored powder readily soluble in water. It takes up moisture from the air, hence must be stored in a tight container in a dry place. A 40-percent aqueous solution is also available and is convenient to use.

Sodium oleyl sulfate is a brown liquid, readily soluble in water.

Sodium lauryl sulfate is a white granular or flakelike material. It may also be obtained in a paste form.

With the exception of sulfonated vegetable oils, the above materials are preferable to soap when used with hard water.

These wetting or spreading agents are useful in getting into suspension certain insecticides which are difficult to wet with water—for example, in making spray suspensions of powdered derris or cube root. Like soap, these materials increase the effectiveness of certain contact sprays by improving their wetting qualities. They are sometimes used in the preparation of "rotenone" dusts.

Numerous proprietary protein spreaders are available for use in obtaining more uniformly distributed deposits of lead arsenate and other stomach poisons, with which this class of material is generally used. If such materials are used, the manufacturer's directions should be followed. Soybean flour, wheat flour, blood albumin, and powdered skim milk are examples of protein spreaders.

When spreaders are used with stomach poisons there is danger of reducing the deposits to too thin a film if excessive quantities are employed. For example, from ¼ to ½ pound of soybean flour per 100 gallons is usually adequate.

Stickers, or adhesives, such as oils or glue, which may have some spreading action, are sometimes added to make the insecticide adhere to the foliage. These materials are often used with lead arsenate and other stomach poisons sprayed on ornamentals and trees to insure a better and more lasting coverage of the plant surfaces, but they are little used on vegetables.

ZINC ARSENITE

The domestic manufactured product, known as zinc arsenite, usually considered as containing $Zn_3(AsO_3)_2$ and an excess of zinc oxide, is a white powder which is colored pink for the insecticide trade. It is nearly as toxic to insects as paris green and ranks close to lead arsenate in adhesiveness. The arsenic content is equivalent to about 40 percent of arsenic trioxide (As_2O_3). Except under certain conditions this material cannot be applied to plants with tender foliage, since arsenical burning results. It has been used for controlling chewing insects on potato, and in Colorado it is used, at the rate of 2 pounds to 100 gallons of spray, for the control of the Mexican bean beetle.

Caution.—Zinc arsenite is a very poisonous compound and must be clearly labeled and stored away from all food products.

PREPARATION OF SPRAYS AND DUSTS

Dusts and sprays usually contain a relatively small proportion of the killing agent, or insecticide. The greater proportion of most dusts consists of carriers or inert materials which give bulk to the mixture and permit a more uniform distribution of the insecticide.

In preparing sprays, small quantities of insecticide are added to water. Often other ingredients are included to increase the spreading and sticking qualities and thereby the effectiveness of the active ingredients. When preparing sprays, carefully follow directions.

Do not practice the old maxim "If a little is good, more is better." Excessive quantities of wetting agents may increase the run-off of the spray and thereby actually decrease the efficiency of the material. Excessive quantities of insecticide in the spray greatly increase the cost and may injure the plants as well as waste strategic materials.

As sold by dealers in garden supplies, many spray preparations contain the essential ingredients in concentrated form, ready for dilution with water and application to plants. Where only small quantities of insecticides are required, it may be more practical to use such prepared spray or dust mixtures than to purchase the ingredients separately. The latter procedure is usually more economical in commercial practice where large quantities are used. It may be possible for gardeners to make group purchases of insecticides in larger quantities at lower prices and to mix dusts cooperatively. Such procedures save in cost of materials and time.

If proprietary insecticides are used, select those labeled to show the active ingredients. Reliable companies have usually tested their products sufficiently so that confidence can be placed in their recommendations.

A set of measuring spoons, measuring cups, and a gallon measure calibrated in pints and quarts should be provided for accurately measuring the materials. Larger utensils are of course required if considerable quantities of insecticide are to be applied. Such utensils should be retained for this purpose only.

The chance of error is greater in measuring dry materials than in measuring liquids because of differences in compactness and density of different brands. Whenever possible the quantities of dry ingredients should therefore be determined by weight. Before measuring a dry ingredient in small quantities, free it of lumps and compactness by stirring or screening. After filling the measure, scrape off the excess with a straight-edged piece of wood, such as a pot label.

QUANTITY OF SPRAYS OR DUSTS TO APPLY

Table 1 gives information on the quantities of liquid insecticides and dusts, such as lead arsenate, calcium arsenate, derris, nicotine sulfate, and other materials, that are necessary to treat row crops at the different rates per acre. Normally an acre of crop grown in rows, such as beans, potatoes, cabbage, and similarly grown plants, requires from 75 to 150 gallons of liquid spray, depending on such factors as the nature of the crop, the size of the plants, and the thickness of the growth or stand. On an average, however, from 100 to 125 gallons of liquid spray will cover the plants in an acre satisfactorily. For small gardens approximately 1 to 1½ quarts of liquid spray is needed to cover 50 feet of row for each application. Information is also given on the number of feet of row that 1 gallon of spray will cover at application rates ranging from 75 to 200 gallons per acre.

With reference to the application of insecticidal dusts, an acre usually requires from 15 to 25 pounds per application, with an average of about 20 pounds. The variation is subject to the same factors as to crop, size of plants, thickness of the stand, and nature of the dust

mixture as indicated for sprays. For example, in the case of the Mexican bean beetle the derris or cube dust mixture is applied at a rate of 20 to 25 pounds per acre. For small gardens from 1 to 1½ ounces is required to treat 50 feet of row crop for each application.

In most cases the standard dilution at which the spray is employed is given in the dicussion under the respective insecticides.

Table 2 presents information concerning the quantities of some of the common insecticidal materials that should be used in preparing 1 and 3 gallons on the basis of the standard dilutions normally employed.

As an additional aid, especially to the home gardener who may not have scales available for weighing out the material, information is given in table 3 in regard to volume, expressed in teaspoonfuls, tablespoonfuls, or cupfuls, of given weights of insecticidal materials that are used in making up small quantities of the commonly used sprays or dusts. For example, if the recommendation is for 1 pound of lead arsenate per 50 gallons of water, use 4½ cups; or in case of 1 gallon, use only 1½ tablespoonfuls.

Table 4 contains a series of tables of liquid and dry measures and equivalents that should be helpful in preparing insecticides when dilutions by parts are given and also when it is desired to prepare various quantities of spray ranging from 1 to 100 gallons.

TABLE 1.—*Approximate rates of application of insecticides to row crops (based on rows planted 3 feet apart)*[1]

SPRAYS

Gallons per acre	For 100 feet of row	1 gallon will cover—
	Quarts	*Feet of row*
75	2	194
100	3	145
125	3½	116
150	4	97
175	5	83
200	5½	73

DUSTS

Pounds per acre	Required for 100 feet of row	1 pound will dust length of row indicated	1 ounce will dust—	
			Length of row	Area
	Ounces	*Feet*	*Feet*	*Square feet*
10	1.1	1,452	91	272
15	1.6	968	60	181
20	2.2	726	45	136
25	2.8	581	36	109
30	3.3	484	30	91
35	3.8	415	26	78

[1] Application rates for fruit trees, small fruits, and shrubs vary considerably with the size of the plants, the density of the foliage, the time of the season, and the insects involved. Apple trees 2 or 3 years old may require only about 1 gallon; mature trees of large size may require more than 50 gallons.

TABLE 2.—*Quantities of some common insecticidal materials required for small quantities of sprays, based on generally accepted formulas*

Material	With 1 gallon of water	With 3 gallons of water	With 100 gallons of water
			Pounds
Calcium arsenate	3½ tablespoonfuls [1]	11 tablespoonfuls or ⅔ cup	4
Lead arsenate	3 tablespoonfuls	9 tablespoonfuls or ½ cup	4
Magnesium arsenate	7 teaspoonfuls	7 tablespoonfuls	4
Paris green	1½ teaspoonfuls	1½ tablespoonfuls	2
Tartar emetic	1½ tablespoonfuls	2 ounces or 4½ tablespoonfuls	4
Derris powder (4 percent)	1 tablespoonful	3 tablespoonfuls	[2] 1
	5 tablespoonfuls	15 tablespoonfuls or 1 cup	[3] 5
Cryolite	7 teaspoonfuls	7 tablespoonfuls	6
Hellebore	5 tablespoonfuls	1 cup	6
Brown sugar	⅔ cup	8 ounces or 1⅔ cups	16
Copper sulfate	6½ teaspoonfuls	6½ tablespoonfuls	8
Hydrated lime	6 tablespoonfuls	1 cup	12
Calcium caseinate	2 tablespoonfuls	⅓ cup	4
Flour	2½ tablespoonfuls	½ cup	4

[1] All measurements are level, not heaped or rounded.
[2] These dilutions give a rotenone content of approximately 0.005 percent in the completed spray. For a rotenone content of 0.01 percent, the quantities given should be doubled.
[3] These dilutions give a rotenone content of approximately 0.025 percent in the completed spray.

TABLE 3.—*Volumes of given weights of insecticidal materials, for determining amounts to be used for making up small quantities of sprays or dusts*

Material	Volume of materials required to weigh—		Material	Volume of materials required to weigh—	
	1 ounce	1 pound		1 ounce	1 pound
	Unit	*Cups*		*Unit*	*Cups*
Bentonite	2½ tablespoonfuls	2½	Magnesium arsenate	4 tablespoonfuls	4
Brown sugar	3½ tablespoonfuls	3½	Mercuric chloride	1 tablespoonful	1
Calcium arsenate	5 tablespoonfuls	5	Naphthalene	5 tablespoonfuls	5
Calcium caseinate	2⅔ tablespoonfuls	2⅔	Nicotine sulfate	5 teaspoonfuls	2
Chalk	6 tablespoonfuls	6	Paradichlorobenzene	2½ tablespoonfuls	2½
Copper sulfate (powdered).	5 teaspoonfuls	1⅔	Paris green	1½ tablespoonfuls	1½
			Pyrethrum powder	5 tablespoonfuls	5
Cryolite	8 teaspoonfuls	2⅔	Soap powder	6 tablespoonfuls	6
Derris powder	6 tablespoonfuls	6	Sodium arsenite	1⅓ tablespoonfuls	1⅓
Flour	4 tablespoonfuls	4	Sulfur (superfine, flowers of).	2½ tablespoonfuls	2½
Hellebore	5 tablespoonfuls	5			
Hydrated lime	3 tablespoonfuls	3	Sulfur (wettable)	8½ teaspoonfuls	3
Kaolin	4 tablespoonfuls	4	Tartar emetic	6½ teaspoonfuls	2
Lead arsenate	4½ tablespoonfuls	4½	Tobacco dust	6 tablespoonfuls	6

TABLE 4.—*Tables of measures*

LIQUID MEASURE

5 milliliters =1 teaspoonful.
3 teaspoonfuls =1 tablespoonful.
2 tablespoonfuls =1 fluid ounce.
8 fluid ounces =1 cup.
2 cups =1 pint.
8 pints =1 gallon.

EQUIVALENT QUANTITIES OF LIQUID INSECTICIDAL MATERIALS WHEN MIXING BY PARTS

Quantity of water (gallons)	Dilution			
	1 to 400	1 to 800	1 to 1,000	1 to 1,600
100	1 quart	1 pint	12.8 fluid ounces	½ pint.
25	8 fluid ounces (1 cup)	4 fluid ounces (½ cup)	3.2 fluid ounces	2 fluid ounces.
5	1.6 fluid ounces	5 teaspoonfuls	4 teaspoonfuls	2½ teaspoonfuls.
1	2 teaspoonfuls	1 teaspoonful	¾ teaspoonful	½ teaspoonful.

TABLE 4.—*Tables of measures*—Continued

EQUIVALENT QUANTITIES OF LIQUID INSECTICIDAL MATERIAL FOR VARIOUS QUANTITIES OF WATER

Quantity of water (gallons)	Quantity of material				
100	½ pint	1 pint	1 quart	2 quarts	1 gallon.
25	2 fluid ounces	4 fluid ounces	8 fluid ounces	1 pint	1 quart.
5	2½ teaspoonfuls	5 teaspoonfuls	1.6 fluid ounces	3.2 fluid ounces	6.4 fluid ounces.
1	½ teaspoonful	1 teaspoonful	2 teaspoonfuls	4 teaspoonfuls	1.3 fluid ounces.

Example: If the manufacturer recommends 1 quart to 100 gallons of water, the home gardener should use 2 teaspoonfuls to 1 gallon of water.

DRY MEASURE

3 level teaspoonfuls =1 level tablespoonful.
16 level tablespoonfuls=1 cup.

EQUIVALENT QUANTITIES OF DRY INSECTICIDAL MATERIAL FOR VARIOUS QUANTITIES OF WATER

Quantity of water (gallons)	Quantities of material					
100	1 pound	2 pounds	3 pounds	4 pounds	5 pounds	6 pounds.
25	4 ounces	8 ounces	12 ounces	1 pound	1 pound, 4 ounces	1 pound, 8 ounces.
5	0.8 ounce	1.6 ounces	2.4 ounces	3.2 ounces	4 ounces	4.8 ounces.
1	0.15 ounce	0.3 ounce	0.5 ounce	0.6 ounce	0.8 ounce	1 ounce.

Example: If the label on a package suggests 4 pounds per 100 gallons of water, the home gardener should use 0.6 ounce (or approximately 3 tablespoonfuls in case of lead arsenate) to 1 gallon of water.

SPRAYING AND DUSTING EQUIPMENT

Many types of sprayers, dusters, and accessories are obtainable for use in applying insecticides. These range in size from those suitable for the home gardener to those adapted for the large commercial grower. Certain commonly used types are discussed below.

SPRAYERS

Hand atomizers.—These are the familiar sprayers (fig. 1) used for applying fly sprays in the home. Usually they hold from a half pint to a quart or more of material. They are useful for spraying house plants or very small outdoor plantings and are generally available locally.

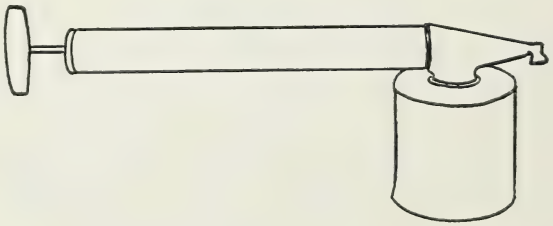

FIGURE 1.—Hand pump atomizer.

Compressed-air sprayers.—Compressed air sprayers (fig. 2) are usually made of brass or galvanized sheet steel and have a capacity ranging from 1 to 5 gallons. The sprayer consists of an airtight tank into which is clamped a pump. In operation the tank is filled with spray to about three-fourths of its capacity, and the opening is closed by a tight-fitting cap. Air is then pumped in by hand until sufficient pressure is developed to force the liquid through the hose and nozzle. The hose is usually fitted with a spray shut-off and a 1- to 5-foot extension rod with nozzle. Since the pressure decreases as the spray is forced out, it is necessary to renew it by further pumping. The tank must be shaken frequently to keep the ingredients well mixed, although the movement of the operator causes a certain amount of agitation.

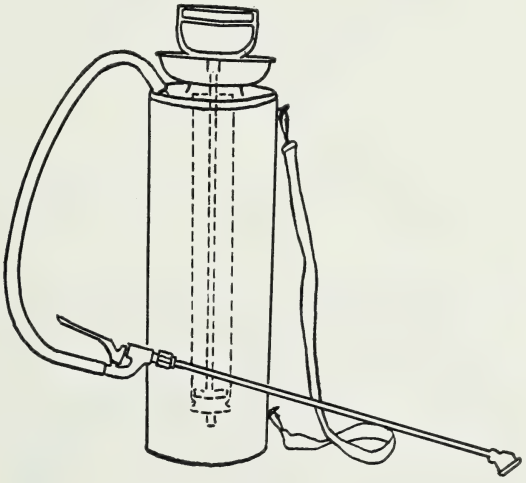

FIGURE 2.—Compressed-air sprayer.

This type of sprayer is suitable for the average home gardener. By the use of extension rods low trees can be sprayed.

Knapsack sprayers.—A knapsack sprayer (fig. 3) consists essentially of a force pump with an air chamber fitted to a metal tank and so designed that it can be carried on the back of the operator. It can be operated by one hand while the other is used to manipulate the spray rod and nozzle with which the apparatus should be equipped. A knapsack sprayer has a capacity of about 3 to 5 gallons and a spraying range of about 25 feet when equipped with a nozzle throwing a compact stream of spray. It has an advantage over the compressed-air sprayer in that a higher and more uniform pressure can be maintained when the pump is kept in constant operation. Agitation is provided in some outfits by a brass plate inside of the tank which moves up and down with the pump handle.

The usefulness of knapsack sprayers corresponds closely to that of compressed-air sprayers. They can, however, be used on larger plantings and on somewhat larger trees.

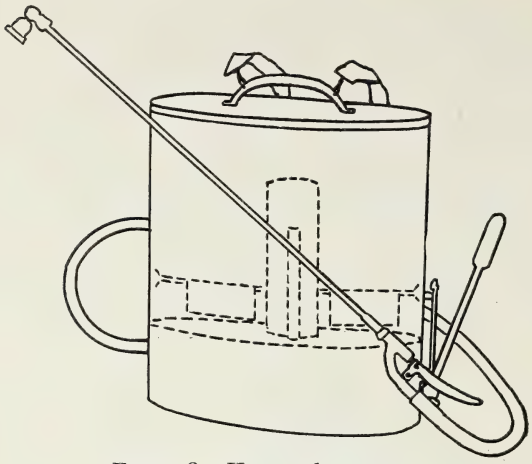

FIGURE 3.—Knapsack sprayer.

The bucket pump.—This apparatus is also called a stirrup pump. It is merely a single- or double-acting pump equipped with hose and nozzle (fig. 4) which may be clamped or set in a bucket or tub con-

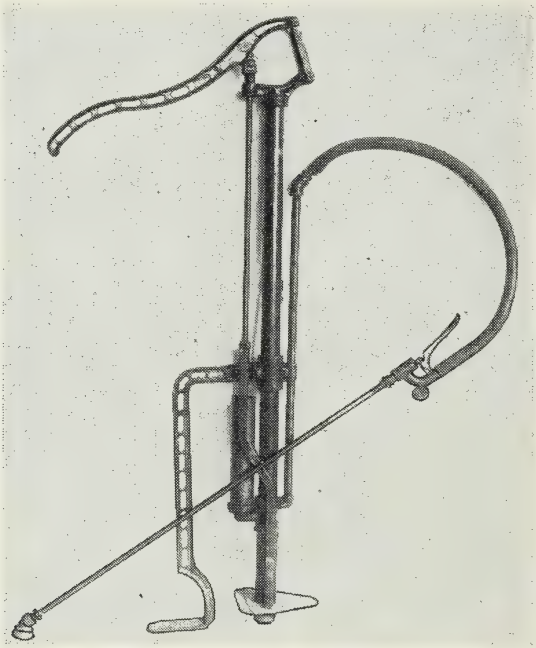

FIGURE 4.—Bucket pump with hose, extension rod, cut-off, and nozzle.

taining the liquid insecticide. This type of sprayer is intended for the home gardener. Its chief shortcoming is the fact that the operator must remain stationary while pumping.

The barrel pump.—This type of sprayer has a hand-operated pump attached to a barrel or similar container for the spray. The assembled outfit is mounted on a sled or wheels (fig. 5) or loaded in a wagon or truck. In certain types, called wheelbarrow sprayers, the container is small enough so that it is mounted between handles with a single wheel in front and is pushed by the operator.

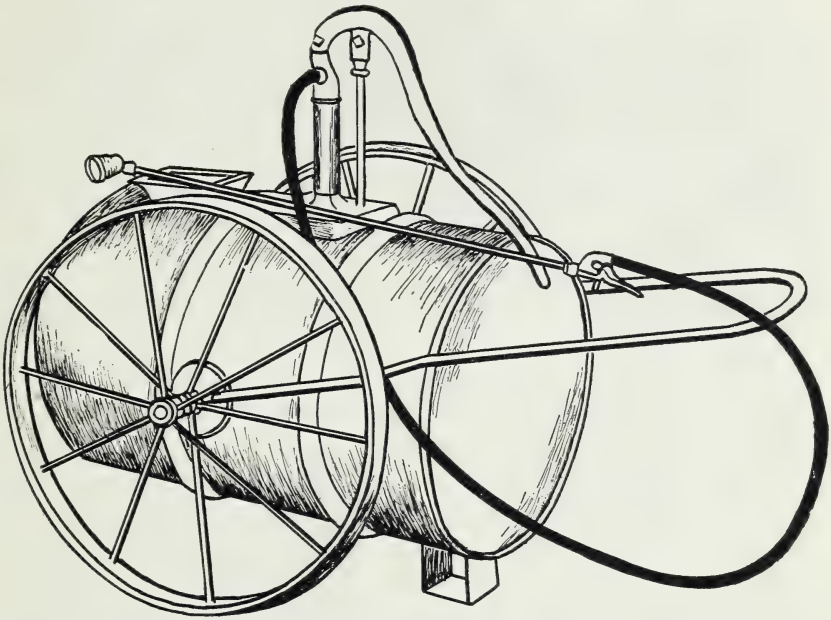

FIGURE 5.—Barrel pump mounted on wheels and equipped with hose, extension rod, shut-off, and nozzle.

Depending upon the size of the outfit, the barrel sprayer is fairly satisfactory for spraying commercial plantings of truck, fruit, nursery, or other crops. However, the operation of the pump is laborious, and it is difficult to maintain constant high pressure. Because of these facts a power outfit is to be preferred.

Traction sprayers.—This type of sprayer is usually mounted on two wheels. Essentially it consists of a tank, with a pump geared to the wheels and with the nozzles usually attached to a fixed boom (fig. 6). Ordinarily these machines are horse-drawn. Pressures reaching as high as 125 to 250 pounds per square inch can be maintained, provided that the rig is in constant motion.

Machines of this type were designed for spraying field crops, including potatoes and tomatoes and small fruits, where it is not necessary to make any stops, as is the case when spraying trees. For the most part traction sprayers have been replaced by power machines, the latter being much more satisfactory.

Power sprayers.—These machines are so called because the pumps are driven by motors, either gasoline or electric. They range in size from small 10- to 50-gallon tank-capacity outfits, with single-cylinder pumps which maintain a pressure of 150 to 200 pounds, to large rigs

FIGURE 6.—Traction sprayer in operation. The nozzles are arranged so as to cover the entire plant with liquid insecticides. When poisonous sprays are being used, the operator should use full face and respiratory protection.

(figs. 7 and 8) for use in orchards and parks, which have a tank capacity of 400 gallons or more and multiple-cylinder pumps which maintain pressures up to 800 pounds.

FIGURE 7.—Large power sprayer in action, with home-made boom attached and carrying 56 nozzles.

The small outfits are usually pulled or pushed by a workman and are used in small commercial plantings of vegetables, ornamentals, and small fruits, and in greenhouses. The larger types are either horse- or tractor-drawn, or they may be self-propelled.

For use on row crops the nozzles are usually attached to a fixed boom (figs. 6 and 7) and are adjusted to spray the plants thoroughly. To spray trees or shrubs (fig. 8) one or more lengths of hose are attached, and the spray is directed as desired by an operator who manipulates the spray gun or spray "broom."

Power sprayers are the most satisfactory for the commercial grower. Numerous types are available, and the individual grower can ordinarily obtain one suited to his particular needs.

FIGURE 8.—Power sprayer in operation in an orchard.

DUSTERS

Cheesecloth sack.—When a regular duster is not available, certain insects on low-growing row crops can be controlled by shaking the powdered insecticide onto the plants from a cheesecloth or similar bag. This method is not very effective for insects which feed on the under sides of the leaves, and is wasteful.

Plunger-type dusters.—The plunger type of hand duster (fig. 9) consists of a chamber for the insecticide and a cylindrical metal chamber provided with a piston, piston rod, and handle. When the handle is operated back and forth an air current is developed that passes through the second chamber containing the insecticidal dust. In some types the pump and the dust chamber are made entirely of metal, whereas in others the dust container is a glass mason jar, which is threaded so that it can be screwed onto the pump chamber. These usually have a capacity of about 1 to 2 pounds.

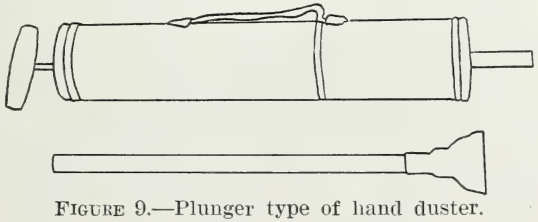

FIGURE 9.—Plunger type of hand duster.

This type of duster is well suited for dusting vegetable and ornamental plants in the home garden.

Bellows or knapsack dusters.—This type of duster (fig. 10) is carried on the back like a knapsack. Essentially it consists of a metal hopper for the insecticide, equipped with a bellows which when operated forces air through a discharge chamber and pipe, carrying the insecticide with it. The hopper is usually provided with a dust-feeding device. The

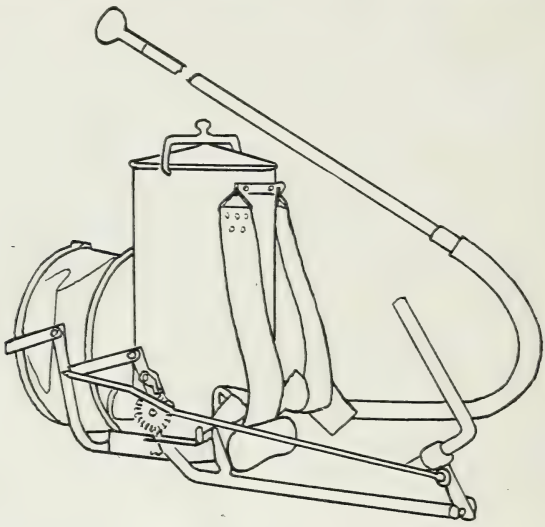

FIGURE 10.—Bellows or knapsack duster.

dust is discharged in puffs with each stroke of the bellows. This type of equipment is especially suited for use on crops planted in hills.

Bellows-type dusters are adapted for use in a variety of situations, from the home garden to good sized commercial plantings. However, they are probably best suited for use by commercial growers in plantings where the use of power equipment is not feasible.

Fan or blower type of duster.—In this type of duster (fig. 11) the hopper, which has a capacity of 5 to 10 pounds, depending upon the powder used, is usually located over the air chamber. An enclosed fan geared to a hand crank forces an even and continuous flow of air

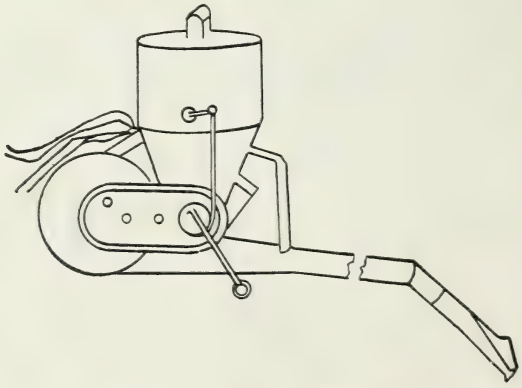

FIGURE 11.—Fan or blower duster.

through a small chamber, into which the dust is fed from the hopper. Most modern types are equipped with an agitator that keeps the dust stirred within the hopper and also with an adjustable feeding device to insure an even feed through the discharge chamber. This type of duster can be fastened to the operator by means of a body support and a waist-and-shoulder strap. The discharge pipes of some are designed so that dusting can be done either in front or to the rear of the body.

This is a convenient and easily operated apparatus for use in situations similar to those described for the bellows duster. Since a continuous stream of dust is delivered, this type of duster is better suited for closely planted crops than for crops where the plants are widely spaced.

Traction dusters.—As with traction sprayers, these machines are geared to the wheels. The principal parts are the hopper for holding the dust, feeder, air chamber, fan, and discharge tubes. They range in size from small outfits pushed by the operator to larger horse-drawn machines.

They are used principally on row crops and small fruits. In general the dust is delivered in the manner described above for fan or blower dusters. Traction dusters are not so satisfactory as power dusters.

Power dusters.—These dusters are operated by gasoline engines and, like power sprayers, range in size from the small wheelbarrow type (fig. 12) pushed by the operator to large horse- or tractor-drawn rigs (fig. 13). Some outfits are mounted directly on tractors.

FIGURE 12.—Small power duster, pushed by hand.

The essential parts are the hopper, feeder, air chamber, fan, and discharge tube or tubes. The dust mixture is carried in the hopper, from which it is fed into the dust chamber, where it is caught by a strong current of air and is expelled through the flexible discharge tubes. The apparatus should have an agitator to stir up the dust so that it will feed evenly. There should also be a device for regulating the flow of dust into the discharge chamber. Power dusters are suited

for use on plantings varying from one-half acre to many acres, depending upon the size of the machine. Hoods or cloth trailers are often used behind the machine on low-growing crops to obtain better plant coverage and to reduce (often by as much as one-half) the quantity of dust required.

FIGURE 13.—A power duster in operation. When poisonous dusts are being used, the operator should use full face and respiratory protection.

CARE OF INSECT-CONTROL DEVICES

Proper care of spraying and dusting equipment is essential to assure satisfactory performance and long life, especially during the present emergency. All equipment should be kept clean.

Sprayers.—Unused spray material should be drained from spray pumps and hose at the completion of a job. The tank, hose, valves, and nozzles should be thoroughly flushed with clean water and the pump run for a few minutes to rinse thoroughly and remove all the insecticide. Unless this is done, these parts and connections may corrode or become clogged. Spray equipment should be kept in a cool, shady place to avoid rapid deterioration of gaskets, hose, and other parts. During cold weather the pump, tank, and hose should be drained of all excess liquid to avoid freezing and breaking, or the sprayer should be stored in a warm place. All unpainted metal parts that are subject to rusting should be well oiled or greased. Wooden tanks should be stored in a damp place or clean water kept in them (except where freezing temperatures occur) to prevent drying out and shrinking.

It is advisable to have extra hose connections, pump gaskets, cup leathers, valves, valve seats, plungers, and other working parts on hand for prompt replacement in case a break-down occurs.

Dusters.—Dusters should be kept in a dry place, and, if used irregularly, the excess dust should be removed after each operation and returned to the container in which it is stored. The dust will deteriorate less rapidly in such containers, and the mechanism of the dusting equipment will not be subject to corrosion. Working parts should be properly lubricated.

WHEN AND HOW TO APPLY INSECTICIDES

Be prepared to spray or dust whenever an insect infestation threatens the crop. Where only a few plants are concerned it may be sufficient to pick off and kill the insects or to remove infested leaves. Find out what insect is present and whether an insecticide should be used; your county agent, Smith-Hughes teacher, extension entomologist, or experiment station entomologist, State department of agriculture, or the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture can give you the necessary information.

To get the best results in the control of insects, the spray or dust mixtures must be properly prepared, and the application must be made promptly and thoroughly with good apparatus. Disregard of these factors involves waste of material, possibly injury to the plants, and questionable results. Do not wait until the plants are seriously injured, but begin the treatment as soon as insects or damage is observed. Using a watering pot or whisk broom is not spraying and is a hit-or-miss method that covers the plants only partially. The ideal spray is a fine mist, and the best work is done when the entire plant is thoroughly and evenly covered with very fine droplets. In case of dusts an even and thin coating of the dust particles over the plant surfaces is desired. The best results are accomplished by directing the sprays or dusts from below to cover the under surfaces of the foliage and from above to cover the upper surfaces. It is best to stop spraying before the foliage is drenched, otherwise large droplets will form and run off the plant, causing wastage. Spraying with a high pressure gives the best results. It is essential to keep the spray mixture stirred during the spraying process.

The interval between applications will depend upon the weather and the habits of the insects. If rains occur soon after the plants have been sprayed or dusted, it is often necessary to repeat the treatment the next day or as soon thereafter as weather conditions permit. If one application does not give good control, repeat the treatment.

FIRST-AID SUGGESTIONS IN CASES OF POISONING

When handling and using poison, there is a possibility of accident; therefore, the following instructions are given as an aid in cases in which poisons have been taken into the stomach. The first step is to call a physician immediately, informing him, if possible, of the kind of poison taken and the exact time of the accident, so that no time will be lost. In the meantime, first-aid care should be given promptly. As stated in the American Red Cross Textbook on Red Cross Home Nursing (p. 385):

"* * * there are *two aims* in first aid treatment for poisons. They are (1) *dilute* the poison and (2) *wash it out of the stomach.* Someone has suggested that a good slogan for first aid treatment for poisons might be 'flush, drain, and refill.'

"First Aid Care—

"1. *Flush* by giving a quantity (4 to 7 glasses) of liquid to dilute the poison. Soapsuds, warm salt water, warm soda water, or plain warm water may be used. Milk may be given for corrosive poisons (lye, cresol).

"2. *Drain* by inducing vomiting. This is much easier when the stomach is full. Tickle the back of the throat with the finger to start vomiting.

"3. *Refill* the stomach with fluid and induce vomiting repeatedly until the fluid returns clear.

"4. If the poison taken was corrosive, give soothing drinks such as milk, or milk and raw eggs beaten together, after the stomach has been emptied.

"5. If symptoms of shock are present (extreme weakness, pale face, chill, cold perspiration, weak pulse,) keep the patient lying down; cover him with warm blankets and apply a hot-water bottle, *well wrapped* and *carefully tested* against the face, to see that it is not hot enough to burn the patient. A patient suffering from shock burns very easily."

Caution.—Do not, under any circumstances, give any liquids to a victim who is unconscious. Keep him lying down and warm until a doctor arrives. If breathing has stopped, as from gas poisoning, artificial respiration should be resorted to, provided it is applied by someone who is competent to apply it.

PROCUREMENT OF INSECTICIDES AND SUBSIDIARY MATERIALS

Ordinarily insecticides, subsidiary materials, and equipment for their application may be obtained from local seed or agricultural supply stores; but if they cannot be bought locally, information regarding sources of supply can be obtained from your county agent, Smith-Hughes teacher, State agricultural experiment station, State department of agriculture, or the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, United States Department of Agriculture, Washington, D. C.

APPENDIX

2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane, known as DDT

A recently introduced insecticidal material, now known to the trade and users as technical DDT, consists largely of 2,2-bis-(*p*-chlorophenyl)-1,1,1-trichloroethane, which has the formula $(C_6H_5Cl)_2CH \cdot CCl_3$, and contains as the principal impurity an isomer thereof. The pure compound is a colorless, crystalline solid which melts at 108° C., but the commercial product is a white powder, sometimes rather lumpy and sticky, which melts at a considerably lower temperature. DDT was first prepared in 1874 by a German chemist, but its insecticidal properties were not known until discovered by Swiss investigators about 1940. Research conducted at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine led to the recommendations of DDT to military authorities for the control of the body louse and other important pests of man, and during 1943 and 1944 it was used effectively in various parts of the world. During the crop seasons of 1943 and 1944 it was widely tested against a large number of pests of agricultural crops, with encouraging results in the case of many insects. Experimental work has not progressed to a point where its recommendation for use on food crops is warranted. Except for limited quantities for experimental purposes, the entire production of DDT is at present devoted to the needs of the armed forces.

Caution.—DDT is poisonous and should be handled accordingly. It has not been definitely established whether or not DDT residue on edible vegetable and fruit products constitutes a health hazard, and until this is determined DDT will have to be considered in the same category as other poisons.

Sabadilla

The term "sabadilla" is applied to insecticides prepared from the ground seed of a group of tropical liliaceous plants known as sabadilla or Indian caustic barley. These plants belong to the genus *Schoenocaulon*, and 20 species have been reported, 3 of which occur in the United States. The seeds of *S. officinale* Schlecht and Champ., imported chiefly from Venezuela, have been used recently in preparing insecticides. The active principle of the seeds is a complex mixture of alkaloids called veratrine (composed of cevadine, veratridine, sabadilline, sabadine, and cevine), found mostly in the endosperm and embryo.

Preparations from sabadilla seed have long been known to be toxic to certain pests of man and animals, and have been widely used in veterinary medicine. Recently improvements have been made in the method of processing the seed, and during the crop season of 1944

large quantities of the insecticide were tested, particularly by the University of Wisconsin, as a substitute for pyrethrum in the control of the potato leafhopper. The insecticide has also been tested against various other insects, including the squash bug and the housefly.

Caution.—The alkaloids contained in sabadilla seed are poisonous. Therefore, care should be taken in preparing and applying sabadilla insecticides. Exposures to sprays and dusts are reported to cause sneezing with many individuals, and with some to cause symptoms of illness, including vomiting.

INDEX OF COMMON NAMES OF INSECTS AND OTHER PESTS

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